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British and German Foundry Statistics

The figures we published recently of German foundry statistics serve to show how much better placed that country is statistically than this. These figures form part of the statistics of the iron and steel industry, and they enable any foundry owner to see how the general trend of business compares with his own. In this way he can see whether his own business fluctuations are in accord with, or contrary to, those of the trade as a whole.

Without repeating the figures, the precise production is given of iron, malleable and steel foundries, and the percentage contributed to the total by the various provinces. The number of foundries, number of employees, number and type of furnaces employed are given. The production is also divided into various parts, so that we know the amount and proportion of the total production of steel castings, malleable-iron castings, and enamelled castings. Thus these sections represent 5.6, 3.3 and 3.6 per cent. of the total production. Grey iron is divided into fourteen groups. The use of scrap is also covered, so that the division of scrap between blast furnaces, steelworks and foundries is evident. The relative proportions of pig and scrap used in the foundries is of great interest.

What is the position in this country? Briefly, the very complete tables furnished by the British Iron and Steel Federation give figures for foundry pig-iron output, and the figure for steel castings production is available. For the rest there is nothing beyond what is disclosed in successive issues of the reports of the quinquennial Census of Production. The third Census in 1924 did not separate the founding from the iron and steel trades as a whole. The fourth Census of 1930 did so for the first time. Figures are given for quantity and value of a variety of products, exports and retained imports and numbers employed for some 800 establishments. The number of foundries is, of course, known largely to exceed this figure, although doubtless the Census figure includes the largest establishments. The Census of 1935, figures for which have been available in preliminary form for about a year, gives somewhat similar figures for a somewhat similar number of establishments. The framework, therefore, for collecting these figures exists, and there seems no reason why it could not be extended to all foundries employing, say, more than ten men, and why important data such as that relating to the use of scrap should not be gathered. Much benefit would be derived if representative people in the trade were consulted before the statistical forms were decided upon.

Continental Research Work

A very profound study should be made by every research organisation, whether privately or publicly controlled, upon the tendencies shown and results obtained by Continental scientific investigation. In this country there is a relative abundance of every sort of raw material available to industry, and as a result there is, generally speaking, a balanced programme embracing every normal activity; but in other countries this is not so, and efforts are being directed towards the maximum utilisation of national resources. Obviously, some developments can be ruled out as unworthy of consideration because inherently they cannot commend themselves as a commercial proposition under "normal" conditions. Others, however, are planned to reduce cost by the minimum use of expensive material and a maximum employment of the cheaper kind. Typical of this is the work being done in Germany on bi-metallic castings. Using the very broadest terms, where a casting has to perform some special duty such as abrasion resistance, only that portion encountering wear is made of special material and the mass of the material is cast in ordinary grey iron or mild steel, as the case may be. Now the French research worker is more inclined to turn to cementation, using all kinds of exotic material to effect the same object.

Another phase, to which Mr. Deschamps has drawn attention from time to time, is the serious wastage that can arise through the use of large risers and feeding heads, due mainly to the cost of removal from the casting and subsequent handling, preparation and remelting. Methods for the reduction of header-loss involve the use of powders based on the endothermic reaction of aluminium; the employment of the electric arc; rational design; the incorporation of splitting-cores; heat-insulating refractories, and the provision of modern machinery for the removal of runners and risers.

Researches designed to ascertain the minimum quantities of special elements essential to bestow definite specific properties are certainly worth close investigation as these are universal in their application, but others entering the category of the replacement of what is to us a cheaper metal by a more expensive one on the grounds that the use of the former does not necessitate a payment to foreign producers can usually be dismissed. The exception is, of course, where the more expensive material yields properties far in advance of the cheaper one.

Whilst "necessity is the mother of invention," these "inventions" need the most careful segregation by countries where "necessity" is absent.

Banded Structure in Cast Materials

By Dr. F. ROLL (Leipzig)

(*Communication from the Testing Department of Meier & Weichelt, Leipzig, and translated from "Die Giesserei," No. 2, 1938.*)

Anyone occupied with the investigation of cast iron which has been exposed to elevated temperatures for a considerable time will occasionally find periodically alternating structures in polished specimens. Such periodic structure formations are to be met with still more frequently, however, in malleable cast iron. Very little has been published hitherto regarding such peculiar rhythmic structures in polished specimens, and it would therefore appear of interest to discuss them.

First Specimen of Cast Iron

Rhythmic banding of pearlite and ferrite in a number of polished specimens was dealt with in a Paper by Sipp and Bauer[1] placed at the writer's disposal. Thus, Fig. 1A shows a casting that had been heated to 850 deg. C. in a gas furnace (Specimen 5 of the Paper referred to). The analysis of the material is as follows:—C 2.15, Si 2.89, Mn 0.44, P 0.22, and S 0.035 per cent. Before heating, the structure of the material was 70 per cent. pearlitic and 30 per cent. ferritic. After the heat-treatment, three zones or bands (Fig. 1A) could be recognised. Oxide inclusions are present in the marginal ferritic layer. The graphite has commenced to dissolve (gasification).

Proceeding towards the core, this marginal layer is followed by an almost pure pearlitic layer which is only slightly broken up by ferrite, while ferrite again appears in the core. The boundaries of the zones are comparatively sharply defined. The content of combined carbon can be estimated from the structure, and the contents thus estimated have been plotted above the photomacrograph in Fig. 1A. With the exception of sulphur, no alteration has taken place in the other elements. The migration of the sulphur was followed by analysis. In the edge layer, the content is about 0.035 per cent. It then rises to 0.075 per cent. in the middle zone and drops to the original value in the core zone. Pearlite has crystallised out in the zone of maximum sulphur content. The sulphur print also shows that the width of the sulphide zone coincides with that of the pearlite ring.

Second Specimen of Cast Iron

This specimen also was heated four times for 10 hrs. at 850 deg. C. (C 2.44, Si 2.80, Mn 0.82, P 0.25, and S 0.026 per cent.). The original structure was likewise composed uniformly of about 80 per cent. pearlite and 20 per cent. ferrite. After heating, the square-section bar exhibits a triple banded structure, similar to that of the first cast-iron specimen,[1] except that the ferrite core is much more pronounced. The estimated contents of the combined carbon, which in this case also stands out relatively sharply from the two ferritic zones in the form of pearlite, are shown above the photomacrograph, Fig. 1B.

Third Specimen of Cast Iron

The purely pearlitic specimen No. 2 (Fig. 1C) after the same heat-treatment exhibits a four-fold banding. The ferritic rim is followed by a very narrow pearlitic zone which gives place to a pearlitic (70 per cent.)-ferritic (30 per cent.) band. The core is again pearlitic.

Fourth Specimen of Cast Iron

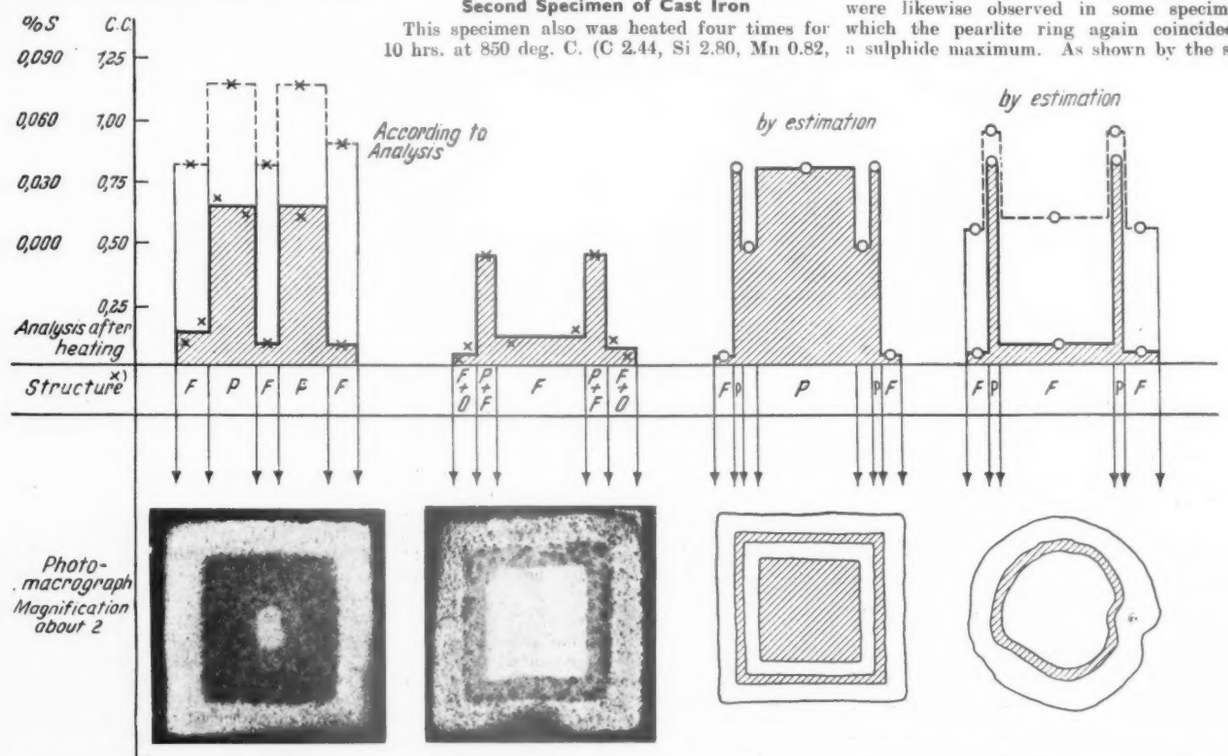
The original structure of this experimentally heated specimen (56) (C 2.99, Si 1.99, Mn 0.34, P 0.25, and S 0.052 per cent.), Fig. 1D, is pearlitic. In the photomacrograph, a narrow pearlitic ring divides the ferritic ground-mass after heating into a narrow outer zone and a large inner zone. The combined carbon content was judged by estimation, while the sulphur content was determined by chemical analysis. In this case also the area which is darker coloured in the photomacrograph, due to the increased content of combined carbon, coincides with the ring of increased sulphur content as shown by the sulphur print.

Fifth Specimen of Cast Iron

In a further experiment for the investigation of the growth of cast iron, banded structures were likewise observed in some specimens in which the pearlite ring again coincided with a sulphide maximum. As shown by the sulphur print (Fig. 2), the local boundary of the segregated sulphides is very narrow. In the sulphide ring, the sulphur content is about three times the original content. Fig. 2 also shows the exact analytical results.

Sixth Specimen of Cast Iron

Very fine banded structures were observed in the case of a high nickel and copper alloy cast iron electric hot-plate. This plate was heated about 25 times to 950 deg. C. and almost the same number of scale bands could be observed



Specimen	Specimen 5 850°	Specimen 10 850°	Specimen 2 850°	Specimen 56 850°
Analysis of Original material	C = 2,15 Si = 2,89 Mn = 0,44 P = 0,22; S = 0,035	C = 2,44 Si = 2,80 Mn = 0,82 P = 0,25; S = 0,026	C = 2,35 Si = 1,75 Mn = 0,46 P = 0,23; S = 0,106	C = 2,99 Si = 1,99 Mn = 0,34 P = 0,25; S = 0,052
Figure	1a	1b	1c	1d

x) F = Ferrite P = Pearlite O = Oxides

Fig. 1.—Solid Line = Combined Carbon Content. Dotted Line = Sulphur Content.

in the polished section after dismounting the plate. Fig. 3 shows the position of the polished specimen in the plate, and Fig. 4 shows the scale bands running along the ribbed underside of the plate.

Further Specimens of Cast Iron

Fig. 5 shows further examples of banded structure in heated cast iron. Here, again, rhythmic alternations of structure are shown, and these can scarcely be attributed to cooling processes or

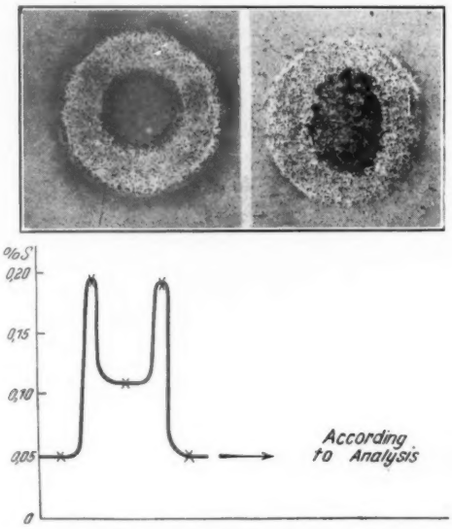


Fig. 2.—Baumann Sulphur Print.

Magnification of about 2, with one sulphur zone, cast iron heated to 850 deg. C. (gas furnace). The analysis and print on the left correspond with one another. The right-hand print was taken from another casting.

the like. As in the case of the structure formations already discussed, the transition from one structure to another is relatively sharp also in these examples. Such banded structure is also frequently to be observed in firebars.[3]

First Specimen of Malleable Cast Iron

Whereas in the case of cast iron, the banding of the structure is a relatively infrequent occurrence, except the banding of the scale,[3] banded structure in the case of whiteheart malleable cast iron is an everyday occurrence, but is not so frequent in the case of blackheart malleable cast iron.[4] In many specimens of malleable cast iron, a narrow ferritic rim is followed by a

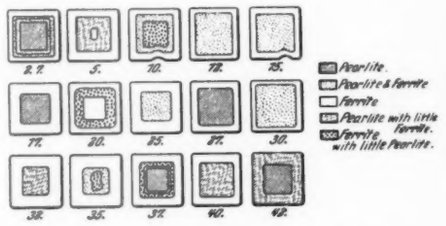


Fig. 5.—Further Examples of Banded Structure in Heated Cast Iron. (From Sipp-Bauer.)

more or less wide pearlitic band. After this there is generally a ferritic layer which gradually merges into pearlite (+ temper carbon) in the centre of the specimen. The narrow pearlitic zone points to recarburisation. The fact that this zone is occasionally more pronounced and sometimes even leads to considerable accumulations of cementite, is related to the particular gas equilibrium. The appearance of such a banded structure is shown in the photomacrograph (Fig. 6) of a whiteheart malleable cast iron (from an open-hearth furnace), above which have been plotted the combined carbon and temper carbon as obtained by estimation. The ferrite band produced on the edge of the casting by the annealing is divided into two areas by the narrow pearlitic seam (carbon drop almost hyperbolic).

Second Specimen of Malleable Cast Iron

The banded structure is still more pronounced in the photomacrograph of Fig. 7, taken from a

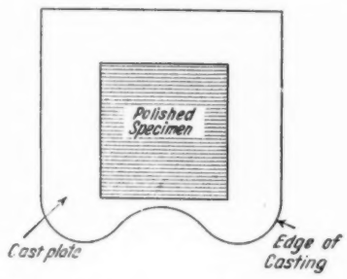
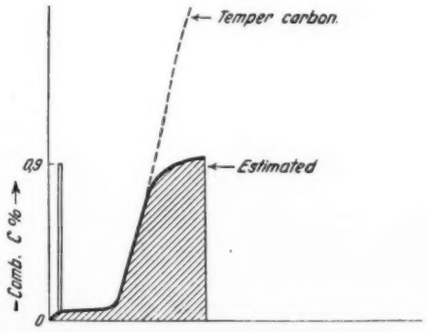


Fig. 3.—Position of Specimen in a Ni-Resist Cast-Iron Plate. Cast Iron Heated at 950 deg. C. (Gas Furnace).

whiteheart malleable cast-iron test-bar (12 mm. diameter) with a black core. The core exhibits ferrite and temper carbon which has not been gasified owing to the rapid decomposition of the carbide. Zones 1, 3 and 5 correspond to the ferritic rim, which is to be expected in the case of the more or less hyperbolic carbon drop. The partial zones 1 and 3 are separated by the



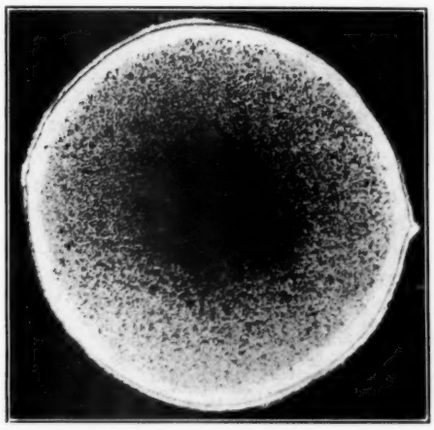


Fig. 6.—Polished Specimen of Malleable Cast Iron with Analysis Diagram.

recarburisation zone 2. Zone 3 has a sharply-defined boundary separating it from zone 4, while the transition from zone 4 to zone 5 is more gradual. The next structure band 6 exhibits a sharp increase in combined carbon. Ferrite with inclusions of temper carbon predominates in the core of the test-bar.

Third Specimen of Malleable Cast Iron

Banded structures are also frequently encountered in "orange-peeled" malleable castings. The edges of such specimens exhibit oxide patches which decrease towards the centre of the casting and then gradually give place to sulphides. These sulphides are located just in front of the sound core and their position can be ascertained by means of sulphur print. Fig. 8 shows the sulphur print of a malleable cast-

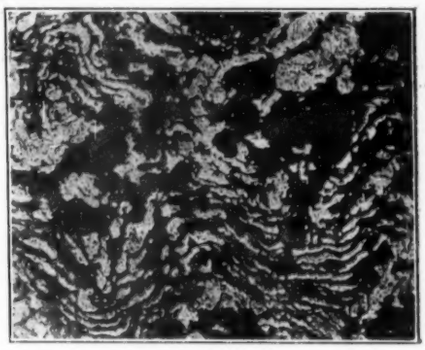
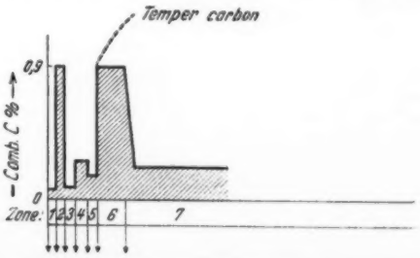


Fig. 4.—Banded Structure in a Highly-Alloyed Cast Iron. × 500.

ing with a "peel" 4 mm. thick. The sulphide ring is strongly pronounced and sharply defined from the still sound core (Fig. 9). This sulphide still contains a maximum amount of pearlite, but in view of the altered conditions, it is not possible to say anything about its formation. In the case of this casting, analysis (Fig. 10) was also effected by zones, the sulphur content increasing to a maximum and then falling again, exactly as was to be expected from the photomacrograph and sulphur print. The amount of



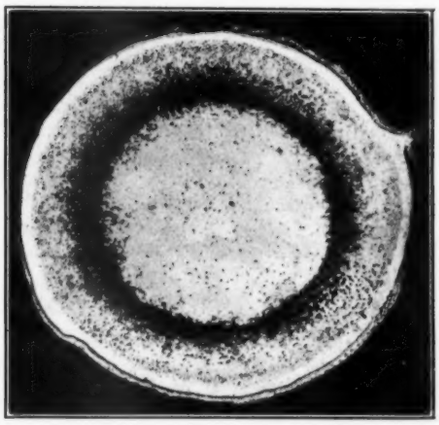


Fig. 7.—Multiple Banded Structure in Whiteheart Malleable Cast Iron.

sulphur is very considerable relatively to the remainder of the ground-mass. Experience confirms that such locally accumulated quantities of sulphur in "peeled" malleable castings are not isolated cases. The combined carbon content has also been plotted in Fig. 10. This content was ascertained merely by estimation, as the

D

small quantities of chippings, particularly in the sulphide ring, made exact analysis difficult. Analysis of the combined carbon is only available for the core of the casting. For the present considerations, however, estimation suffices.

Various Banded Structures

Rhythmic structures are found not only in heated or annealed castings, however, but also in castings which have not been subjected to any heat-treatment, although they are more infrequent. In 1928, in quenching experiments on high-silicon cast iron[8] (analysis: C 3.01, Si 3.45, Mn 0.78, P 0.25 and S 0.075 per cent.), peculiar banded structures of grey and white cast iron were observed. Fig. 11 shows the macro-structure of a bar 30 mm. in diameter and about 350 mm. long. It is characteristic that the zones (Fig. 12A), which in this case also have well-defined boundaries, pass uniformly throughout the entire casting. When the combined carbon of these bands is ascertained, the curve shown in Fig. 12A is obtained. Rhythms other than those of the combined carbon could only be observed in a similar sulphur zone structure which perhaps appeared simultaneously only by coincidence. In considering these crystallisation phenomena, which proceed contrary to the other cooling conditions, one is reminded of the inverse chilled cast iron which was particularly troublesome shortly after the war, but which usually did not appear in banded formations. It is also necessary to mention here the observation made on quenching barely-solidified castings in water so that cementite appears in the centre of the casting, although these single band structures, as they may be termed, can only approximately be compared with the rhythmic structures shown in the photographs reproduced above.

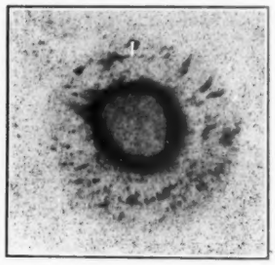
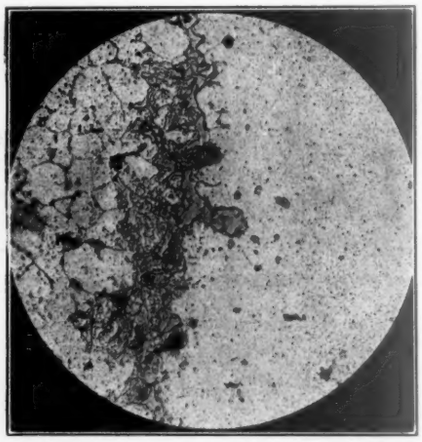


Fig. 8.—Baumann Sulphur Print.



Band I.	Band II.	Band III.
Considerable oxide inclusions.	Peel zone with much sulphide and pearlite.	Ferrite core with no increase in oxide or sulphide.

Fig. 9.—Structure Zone in Front of the Sound Core.

Rhythmic structures were also produced in steel ingots in the shaking tests carried out by Herzog.[6] Such rhythmic structures can be recognised both from the analysis of the carbon, phosphorus and sulphur and from the sulphur print. Strangely enough, the analysis of the manganese failed to show the difference actually to be expected. Herzog does not provide any explanation of this. A rhythm is observed more frequently in the crystal form (globulitic and columnar crystallisation) in light metals, copper and other metal alloys. L. Northcott[7] *inter alia* by preliminary investigations on potassium bichromate endeavoured to draw a parallel with the aid of a substance that is more accessible to observation. He explains the banding between columnar and globulitic crystals by a rhythm of structure impurities during solidification. The periodicity is thus relegated to the domain of crystallisation processes. Whether this completely explains the periodic solidification appears doubtful for the very reason that metals which contain considerable amounts of impurities seldom exhibit a tendency to rhythmic solidification, whereas pure metals, particularly in the form of chilled castings, do occasionally possess such a tendency. Furthermore, Northcott's explanation fails to take into account the peculiarity of other similar crystal rhythms.

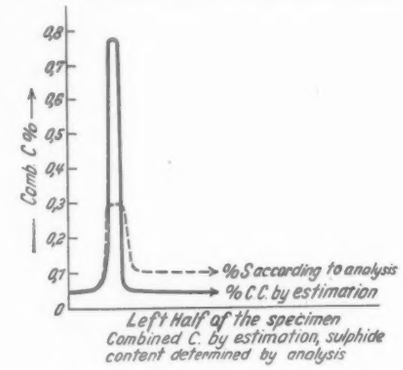


Fig. 10.—Sulphur Analysis of the Casting.

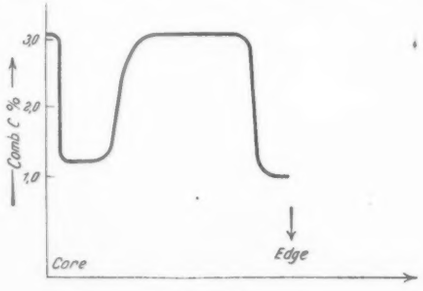


Fig. 12A.

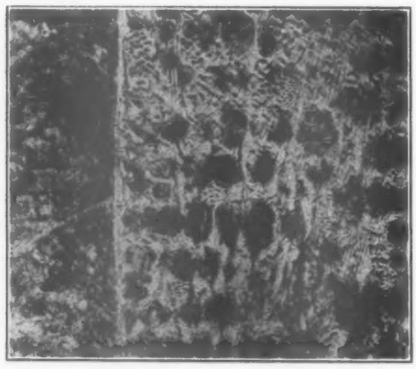


Fig. 12B. (× 200.)

Figs. 12A and 12B.—Rhythm of the Combined Carbon along the Radius.

Reference has also been made in the literature to rhythmic crystal formations in metals. Thus, Kohlmeyer[8] has observed periodic segregations in lead pipes and Endell[9] has called attention to similar rust phenomena on meteoric iron. Meyer and Hobrock[10] describe very beautiful rhythmic formations of iron nitride crystals and Pfeil[11] shows that very definite local reactions take place in the oxidation of iron. Bauer and Arndt[12] have photographed such structural changes in the reduction of cuprous oxide enclosed in iron by zinc.

Not least of all, mention should be made of the banded eutectics which are encountered everywhere in metallography and which pertain to this domain of rhythmic crystallisation, at least in the external form of the phenomenon.

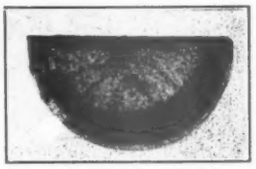
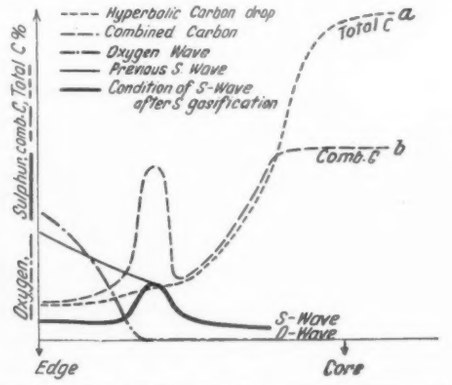


Fig. 11.—Banded Structure in High-Silicon Iron in a Chill Mould. Half a 30-mm. Bar.

Examples of periodic crystallisation become much more abundant, however, if the many often very fascinating forms described so graphically by Liesegang[13] and recently reviewed by E. Hedges[14] are included. However, an explanation of the peculiar banded structures in the metallic substratum is still more difficult than in the case of the periodic formations of jellies and the like,[15] because there is no experimental basis on which to work.

In the metallic substratum, a number of elements usually participate, including, for example, sulphur. The type of reaction which, in accordance with the law of mass action, belongs to "limited" reactions, is peculiar to these structure formations. Likewise, as a general rule, two diffusion waves travelling in opposite directions are peculiar to these banded structures; for example, in the case of malleable cast iron there is the wave of decarburising gas travelling towards the core of the casting and the carbon wave travelling from the core.



Band.	I.	II.	III.
Carburisation equilibria	$2CO \leftarrow CO_2 + C$	$2CO \rightarrow CO_2 + C$	$2CO \leftarrow CO_2 + C$
Sulphurisation	$Fe + H_2S = FeS + H_2$	$Fe + H_2S = FeS + H_2$	—
Oxide formation	$Fe + O = FeO$	—	—
Gasification of sulphur	$3O + FeS = SO_2 + FeO$	—	—

Fig. 13.

(*Concluded on page 312.*)

Improving Steelfoundry Practice*

By J. DESCHAMPS

When asked to give a short Paper on steel castings to the Sheffield Branch of the Institute of British Foundrymen, the author at first hesitated to accept the invitation, because it seemed that there was nothing he could say about the subject which foundrymen in Sheffield—which saw the birth and the more interesting developments of the steelfoundry industry—did not already know. However, it was thought that if the subject were confined to a few aspects of the art of steelfounding which are worth more research and investigation than have taken place hitherto, it would provoke a useful discussion.

It is not intended to deal in any detail with the multitudinous technical problems which confront the steelfounder, or with the various processes employed in the elaboration of the metal, but to limit the Paper to plain carbon-steel castings which, notwithstanding the important developments which have occurred lately in the production of alloy steel castings, still account for more than 80 per cent. of the total output of steel castings in this country.

The fact that steel castings are comparatively recent products is accounted for by the numerous difficulties which are encountered in the course of manufacture, many of which do not arise (or, if they do, to a much lesser degree) in the production of iron castings. As is well known, the melting point of steel is much higher than that of cast iron, and steel castings are poured at temperatures approximating 300 deg. C. higher than iron castings. This necessitates the use of highly refractory sands, namely, sands with a high silica content and only just enough bond to enable the mould to keep the shape of the pattern and to resist the ferro-static pressure of the metal and the tendency to abrasion by the stream of molten steel entering the mould through the runners and gates.

New Processes Available

No description will be given as to the methods with which foundrymen are familiar, and which are now in fairly general use, for the control of the physical properties of steelfounding facing and backing sands, such as the routine determination of the moisture content of the sand, its strength and its permeability, the last being usually a function of its refractoriness, but at this stage mention will be made of two relatively recent processes which are said to be used successfully in the production of steel castings. One of these is the Randupson process, in which, instead of using natural or synthetic silica sands bonded with clay of a more or less colloidal nature, use is made of a mixture of silica sand and Portland cement. The moulds obtained from this mixture are dried in air, and it is possible to produce by that method fairly large castings without the use of moulding boxes.

The other method consists in the use of a mixture of silica sand, linseed oil and bi-oxide of manganese which is applied lightly, without any ramming, on the patterns or in special core-boxes and, whilst developing great hardness through being dried in air, has the property of becoming quite soft and collapsible after having been in contact for a short time with liquid steel, thereby yielding easily to the stresses induced by the solid contraction of the metal, to which difficulty further reference will be made later. The advantages of these new methods will be apparent to all if one considers the ease with which very hard cores can be handled without risk of being damaged during the coring up and closing of the moulds.

The author understands that very clean and accurate steel castings can be produced with either of these sand mixtures with a remarkable absence of cracks or hot tears, even in the case of very intricate castings such as a large and complicated bogie frame for railway carriages.

Reducing Feeder Heads

Another difficulty which has to be overcome in steelfounding is that when passing from a liquid to a solid (or at any rate to a pasty condition) steel is subjected to an appreciable liquid contraction which is usually counteracted by the provision of suitable risers or feeding heads. The extent of this liquid contraction is in the neighbourhood of 6 per cent., and, to deal with this the steelfounder usually uses about 40 per cent. liquid steel in the form of risers. This gives a measure of his inefficiency in dealing with this particular problem of adequate feeding. In other words, with the feeding methods now in general use, the steelfounder wastes about one-third of the liquid steel he requires to produce his castings.

In specific cases, when one is dealing with very large risers on heavy steel castings, one may reduce considerably the amount of liquid steel required for feeding purposes by resorting to the use of what may be described as a portable electric furnace applied to the top of the risers. The heat generated by an electric arc struck between an electrode and the metal in the riser maintains the temperature of the steel in the riser and even augments it so as to ensure that practically the whole of the steel in the riser finds its way into the casting. A case can be cited of a cast steel anvil-block weighing 100 tons, made in a Sheffield foundry, being cast perfectly sound by that method with a total weight of 106 tons of liquid steel. This practical experiment, incidentally, confirms the accuracy of the theoretical amount, namely, approximately 6 per cent. of liquid contraction, determined by laboratory tests.

However, it will be apparent that such a method can only be used economically in a few isolated cases, but the field is open to experimenters who will try other methods of making the risers function more efficiently than they do at present. For instance, although fairly efficient means are employed to retain, as long as possible, the heat and, therefore, the fluidity of the upper layers of the steel in the risers by covering the latter with various compounds producing exothermic reactions when in contact with molten steel, nothing has as yet been done, certainly not to personal knowledge at any rate, with the conservation of the heat in the risers *laterally*. It seems possible, for instance, to evolve a mixture of diatomaceous earth or asbestos, or any other materials possessing great insulating power, and some refractory binding agent to form a mass against which the risers can be moulded.

Potential Savings

To illustrate the amount of wastage of steel in risers of steel castings, where one is using over one-third of steel from the melting furnace to keep about 6 per cent. of it hot and fluid, one could profitably consider the case of a medium-sized steelfoundry producing 100 tons of steel castings per week. To do this, this foundry requires about 160 tons of liquid steel. Admittedly, some of it is used for runners and gates, tie-bars, test-pieces, etc., but assuming that instead of the theoretical 106 tons of liquid steel one succeeded, by employing proper means of heat conservation in the risers, in saving, say, 25 tons of liquid steel per week, this would mean an annual saving of something like £6,000 of £7,000.

Solid Contraction

Another difficulty experienced in steelfoundry practice is in connection with solid contraction. One must bear in mind that when a steel casting is still in the pasty state, namely, prior to complete solidification, it has practically no strength and will readily crack if this free contraction is interfered with either by the sand of the mould being too strong, or rammed too hard, or if the risers and runners are not "eased" in time. This is where the skill of the moulder is best shown. A good moulder will ram his sand indifferently, namely, hard near the pattern and soft some distance away from it, so as to reduce the resistance to contraction, and this is why for large and intricate castings the best results are obtained when they are hand-moulded instead of machine-moulded.

Several methods are employed to facilitate the solid contraction of a casting, such as the "easing" of the sand, or pouring water on the sand on those parts of the moulds which constitute obstructions and thereby transforming this sand into a sort of mud. Apart from the obvious danger attached to the latter method, it is very difficult to know exactly when to add this water and in what amounts. In some cases, particularly with large cores, the use of ashes or coke breeze is resorted to, these collapsible materials being, of course, separated from the faces of the moulds by a layer of refractory sand.

Cores, particularly in light and intricate castings, are often made in oil sand, which is sharp silica sand bonded with oil, molasses, or resin or cereal binders. These binding media burn away and allow the sand to crumble under the contraction stresses.

Cleaning Steel Castings

Some interesting developments have recently taken place in connection with the cleaning of steel castings. Shot-blasting, for instance, is now being carried out with compressed air at a much higher pressure than formerly, pressures of about 75 to 80 lbs. instead of 30 to 35 lbs. per sq. in. now being employed. The mixture of chilled shot and sand removed from the skin of the casting, instead of being evacuated pneumatically, is now dealt with by elevators, thus reducing to a considerable extent the motive power required for this operation.

There have recently come into use machines of the Wheelabrator type in which the chilled shot is projected at very high velocity on the castings to be cleaned, without the intervention of compressed air, by the action of an impeller revolving at high speed, on which the shot is fed. The stream of shot has a constant direction, but the castings are kept moving so as to expose all their faces to the shot by the displacement of the floor of the cabin on which they are supported, which can best be compared with the cover of a roll-top deck. Such machines have, hitherto, been designed to deal with small castings only and are proving very efficient and economical.

Heat-Treatment

There is one phase of steelfounding in which considerable technical progress could be made, namely, the heat-treatment of the castings. Steel castings are generally either normalised or annealed, the main object in view being to relieve the stresses set up by relatively rapid cooling in the moulds, and to refine to a certain extent the crystalline structure, with a consequent improvement in the toughness and elasticity of the metal.

Greatly improved physical properties can, however, be obtained by subjecting the casting in favourable cases to a complete heat-treatment, i.e., quenching in air, oil or water and subsequently tempering at varying temperatures below the critical range. Admittedly, there are some types of intricate and heavy steel castings which would not lend themselves to such treat-

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* Paper read before the Sheffield Branch of the Institute of British Foundrymen.

ment, but if the castings are made from very low carbon steel, in many instances full heat-treatment consisting of quenching in suitable media followed by tempering at a suitable temperature would, without risk of cracking the castings, increase considerably their tensile strength, the ratio between their yield point and their ultimate tensile strength, produce a good elongation and, what is most important, increase considerably their ability to resist shocks.

It is a well-known fact that steel castings, particularly those of fairly high tensile strength, say 35 to 40 tons per sq. in., possess generally very poor shock-resisting properties. The latter are usually determined in this country by the Izod test and depend principally on the grain size of the metal. The finer the crystalline structure of the castings, the better they will resist shocks for a given tensile strength. Such fine grain can be obtained by full heat-treatment, or if the shape of the casting would render quenching dangerous, by some sort of inoculation of the metal when in the liquid condition.

Existing Specifications

The author would definitely favour a revision of specifications in the direction of an appreciable increase in the minima asked for the physical properties, such as tensile strength, elongation, cold-bend test and ratio between yield point and ultimate tensile strength. He would also like to see Izod tests specified for steel castings. After all, when in service, many steel castings are subjected to shocks and the time is coming when users of steel castings will insist upon some considerable improvement in their shock-resisting properties.

The author was present, some months ago, at the reading of an interesting Paper by Prof. Southwell, Oxford University, on the subject of "The Izod Test." It appears that there is some divergence of opinion amongst the authorities as to whether the Izod test actually determines the shock-resisting properties of a given steel, or whether it indicates the degree of ability of the metal to resist the propagation of a crack.

However that may be, the Izod test is the best so far conceived to bring into relief properties of the metal which cannot be ascertained from the static tests of tensile and cold bending which are mainly in use. It is well known that, when resort is made to a drop test to destruction of a steel casting, the higher the Izod figure, the greater is the punishment the casting will take before fracturing. There are means available to obtain from steel castings Izod figures comparable with those now obtained from plain carbon steel forgings of similar tensile strength, and it is submitted that engineers have the right to ask for them, and hope is expressed that they will do so.

Chemical Specifications

On the other hand, it is also submitted that the existing specifications are too stringent with regard to the chemical composition of the steel in particular reference to the amount of sulphur and phosphorus permissible in the metal. After all, what the user of steel castings requires is the maximum possible tensile strength, the highest possible ratio between the yield point and the ultimate tensile strength, coupled with the greatest possible elasticity as indicated by the usual static tests determining elongation, reduction of area (striction) and ability to bend cold without fracture, and also the greatest resistance to shock, fatigue, repeated stresses, etc.

It is not necessary, in order to obtain these optimum results, to resort to very low sulphur and phosphorus contents. Of two given steels of identical chemical composition as far as carbon and manganese are concerned, normalised or annealed the same way, one having, say, 0.02 per cent. sulphur and phosphorus may not be as good as one having, say, 0.06 per cent. sulphur and 0.07 per cent. phosphorus.

The only advantage of having a very low sulphur content such as can be obtained in basic electric steel is that the metal has less tendency to develop hot tears under contraction stresses when in a pasty condition in the mould, but this can be provided against by taking suitable precautions in the moulding. Moreover, these very low sulphur contents can only be obtained from over-reduced steel, the running properties of which are *ipso facto* adversely affected.

What the specifications should call for is that the whole of the sulphur content in the metal be combined to manganese to form the spherical manganese sulphide instead of the chain-like inclusions of iron sulphide. This is where the use of the microscope enters as the necessary adjunct to pure chemical determination.

Regarding phosphorus, it is possible to state that, for low carbon contents at any rate (say up to 0.2 per cent.), far from being detrimental in amounts up to 0.1 per cent., it is actually beneficial, inasmuch as, for a given carbon and manganese content, it increases the tensile strength of the metal without impairing its elongation or its ability to give a good cold-bend test and good Izod figures. It is admitted, however, that this is not the case when dealing with relatively high-tensile steels, the resiliency of which is adversely affected by a high phosphorus content.

Notwithstanding the considerable improvement which has been achieved in recent years in the quality of steel castings which are now being made satisfactorily in shapes and sizes which would have been considered impossible to produce about 30 years ago, it must be realised that further and unremitting effort must be made if steel castings are to maintain the position they have secured amongst structural materials.

Meeting Competition

Apart from the daily increasing competition from forgings and fabricated structures, one must take into account the new synthetic materials of a non-crystalline character which are likely to be developed (although perhaps not in the immediate future) to such a point that they will become serious competitors of steel castings. In this connection, reference can be made to the very interesting remarks on the subject made recently by Prof. Inglis, of Cambridge University, who stated that, "weight for weight, such synthetic materials and also some natural products were much stronger than the best steel we could produce." His remark that a spider's filament on a weight comparison, compared with a steel of an ultimate tensile strength of 560 tons per sq. in., gives an appreciation of the magnitude of the task of the metallurgist if he is to emulate nature in producing a material of a maximum strength with the minimum weight.

It is not thought that metallurgists will ever succeed in becoming as efficient as the spider, but let them not lose heart: let them consider the progress still to be made and find in the magnitude of the task to be accomplished a spur to fresh endeavours.

DISCUSSION

The Branch-President (Mr. J. B. Allan) said the members had heard a most interesting Paper on the production of steel castings in general. He imagined that Mr. Deschamps' views on specifications would prompt several of the members to express their own opinions on the subject. He personally always felt that specifications which included chemical analyses, which certainly had tended to become more exacting, had probably started from purchasers who in the past had found that, with a certain analysis, a particular casting had given good service. From that it had developed until the more scientific minds had tackled the same subject, but they, too, had started at probably the same base. There was no doubt in his mind that in many cases the production of castings, particularly those of steel, had probably been retarded rather than increased by the attempt to tie the manufacturer to a specification which covered both analysis and physical qualities. Actually, the customer was primarily concerned with physical qualities, and all the matter he put in by way of chemical composition was merely his idea how they should be obtained.

Shock Resistance

On the question of shock-resisting qualities, he thought the Izod test in a large number of cases gave them a good indication of the desired properties, and that test was applied even to iron castings in these days. Unfortunately, the range that it was possible to obtain in iron was so limited that the figures in many cases were hardly capable of measurement. Nevertheless, the previous day he had been informed on reliable authority that, after a very large number of experiments with the ordinary Izod machine on test-pieces of ordinary cast iron, it had been possible to obtain figures which were comparative and on which the results were quite consistent. Admittedly, these tests were done very largely under laboratory conditions, which was probably the proper place for them, but at least it held out hope that foundrymen might expect in due course to obtain some method of measuring shock-resisting qualities in cast iron.

Confusion with Malleable

Mr. J. R. Hyde, speaking with reference to the Izod test, said that in the Potteries they used it for testing the porcelain for manufacturing insulators. The man who was responsible for the clay used an Izod impact machine, but had it made only one-tenth strength, and by such a reduction one could not only test cast iron and porcelain, but steel castings in the unannealed state.

In connection with specifications, if only the buyer knew as much as the steelfounders, they could trust him to handle the specification properly; but usually he did not. By increasing the specification they were giving the buyer a weapon he could hit with, and sooner or later he would reject some of the steel castings on paper evidence which had no reflection on the quality of the steel castings. Mr. Hyde urged that the specification should not be altered until they had the inspectors with the knowledge of how to use it. As to reasons why chemical analysis should be specified, one could imitate quite good steel castings with malleable iron, and, unless a simple chemical test were applied, they could "get away" with malleable iron and call it steel. He asked them to retain the specification of chemical analysis as it was to-day, and the steelfounders would do their best to put up with it.

Low-Specification Demand Can Create Confusion

Mr. Deschamps said he feared Mr. Hyde was taking a retrograde view in opposing the demand for a stiffening of the specification. The steel castings industry was competing with forgings. The forging manufacturers claimed for their products so much better physical properties than could be obtained for steel castings, and users would possibly select forgings instead of castings. Steel castings could be made as satisfactory as steel forgings so far as the physical properties were concerned. He did not say one could guarantee them to be as sound, because of certain defects which were to be found sometimes in steel castings. Steelfounders had also to face the competition of weldings and fabricated structures. It would pay them not be satisfied with the comparatively easy specification. If they were satisfied with making a steel of 26 tons tensile with a 20 per cent. elongation it would pass. If users were satisfied with 26 tons tensile they should specify 40 per cent. elongation. It was by looking at the problem from that angle that they were going to maintain and increase the sale and production of steel castings.

whereas if they allowed the existing specification to remain they would sink into oblivion.

Izod tests were often specified for forgings. He contended that steel castings, properly made and properly heat-treated, gave results equal to or approaching those for steel forgings. This was the only country where Izod figures were not required for steel castings in specifications; they were required in some of the Dominions. Mr. Hyde had said that chemical analysis should be retained because it was the only means of distinguishing malleable iron from steel. This was so only so long as they maintained that easy specification, but he submitted that the specification should be much more drastic. Malleable iron would never reach the figures he had given, which were the figures asked for from steel castings.

A New French Process

Mr. S. Leetch thought Mr. Deschamps, after he had read his Paper through, must have said, "This will stir up the steelfounders in Sheffield," for much of the Paper was intentionally provocative. He was interested to hear about the large castings in France. Did Mr. Deschamps infer that the absence of contraction pulls was due to the powder which, he took it, was scattered on the pattern before the moulding sand was put on? Did some fusion take place which strengthened the skin of the steel and made it overcome the resistance of the cores? He was thinking particularly now of a job about 17 tons in weight, 14 ft. square and 4 ft. deep, the main sections being 1 in. thick. He had had considerable experience in making these, and it had been found that the greatest success in overcoming contraction pulls was in paying the greatest attention to the construction of the internal cores, as well as the way the castings were run, the external chilling, and the position and shape of the feeding heads.

Taking Test-Pieces

Mr. Deschamps thought there was much progress to be made in trying to cause the cavity in a riser to be better distributed than it was at the present time. The average riser of, say, 18 in. diameter had a cavity which came to an inverted cone. The fact that it was an inverted cone indicated that the means of maintaining the heat at the surface of the riser were fairly efficient, but laterally they were inefficient. All the steel which was between the apex of the inverted cone and the casting was lost; therefore, if a refractory expert could evolve a mixture of insulating material capable of being moulded against, they would maintain the heat laterally in the riser without having to resort to the method which succeeded in favourable cases of striking an electric arc in the top.

On the question of the Izod test, he had been asked if he would be prepared to guarantee any piece taken from any casting. His answer was very simple. Were they prepared to have a tensile and bend test for any piece? He was not. He said that the Izod should be taken from a test block just as tensile and bend tests were taken.

All steels, by whatever process they were made, contained, after oxidation had taken place, an appreciable amount of microscopic oxides, with the possible exception of basic electric steel. Mr. Deschamps cited the case of a converter steel which was full of oxides before one started deoxidising it, and it was not deoxidised to 100 per cent. By adding to the stream of the steel entering the moulds after deoxidising a controlled amount of aluminium which would combine with the sub-microscopic oxide resembling a cloud of alumina and which would act as millions of little nuclei around which a fine crystallisation would take place, real improvement would be effected. The difficulty was to ensure that the aluminium addition, which was very minute, ranging between 0.05 and 0.07 per cent., was going to be properly distributed. In a casting weighing a ton with the whole of the steel they put in, in order to obtain the optimum effect, they had to add 1.4 lb. of aluminium to the steel and take suitable steps to ensure an even distribution throughout the mass. He had made many experiments in that connection, and the results showed the Izod figure to be doubled and trebled, and the fine-grain structure remained, irrespective of any subsequent heat-treatment. Even with very slow cooling the fine-grained structure remained. When they designed a steel casting they did not design it on the ultimate tensile strength, but used the elastic limit as the base.

The means which were successfully applied to improve the shock-resisting qualities as indicated by the Izod test resulted in a considerable improvement in the ratio between the yield point and the ultimate tensile strength without resort to any drastic heat-treatment, and they achieved for this ratio 70 or 75 per cent. as against the usual 55 to 60 per cent.

The mixture referred to in the Paper was 3 per cent. manganese-bioxide mixed intimately with hot silica sand containing linseed oil.

Electrically-Heated Risers

Dr. C. J. Dadswell said he knew Mr. Deschamps was always searching for means to improve steel castings, and he not only thought about them, but tried them out in practice; that ability to carry out practical researches had no doubt contributed considerably to the success of his firm. Before Mr. Deschamps had mentioned it to him, he had not heard of manganese bioxide in oil sand being used in the connection Mr. Deschamps mentioned—ramming it hot against a pattern or core box. He had heard of the use of MnO_2 in France, where a small quantity had been added to a core binder to assist in the core-drying. He presumed that part of the oxygen from the manganese bioxide assisted the oxidation of the linseed oil. They had tried it, but did not find any appreciable improvement, probably due to the fact that they were using a proprietary core oil which might not have contained as much linseed oil as they thought.

Mr. Deschamps had mentioned his (Dr. Dadswell's) connection with the practice of arcing on the heads of large castings, and he could confirm that the figures on the 100-ton casting were correct. Not only was the process used on castings with one riser, but they had used it with three risers. The process made a considerable saving in steel, and it had a very useful application in a casting on which the top part had two levels. At the present time they had to make a casting which weighed 120 tons in the unmachined state, and that casting had a top part, the level of which dropped 3 ft. at one end. If one was to have adequate heads on the centre portion, it required heads on the lower portion more than twice as deep as necessary, and with heads 30 in. diameter there would be a very considerable loss in steel. One could, of course, make dummy heads, or reduce them by putting smaller boxes on top of the large heads, but there were dangers in doing that when pouring large castings.

Alteration of Specifications

With regard to the Izod test and the specification, he was not quite sure whether he understood Mr. Deschamps properly, but he thought the author had been unnecessarily ambitious in this respect. He did not think it was necessary to make a difficult specification for a large number of steel castings. In many steel castings the ordinary standard specification for mild steel was perfectly adequate, and it was far and away stronger than was really necessary owing to the fact that there were certain minimum thicknesses one had to have for casting and also for rigidity of design.

In the American Association of Railroads specifications there were certain grades for carbon steel castings:—Grade A was an unannealed steel, grade B called for 31.0 tons per sq. in., and recently, owing to the demands for castings of greater strength, a high tensile steel had been introduced which was grade C, calling for 3[illegible] tons per sq. in. U.T.S. They had thus made a grade better than the previous grade which a designer could specify. Mr. Deschamps did not think it was necessary to improve the general specifications as they stood at the present moment, although special demands could be, and were, met. He had some sympathy with Mr. Deschamps in his arguments against a rigid chemical analysis, although he did think that certain limits of analysis were necessary.

Regarding shot-blasting, he recently saw an ingenious machine made specially for one type of casting in which castings 10 ft. long were being cleaned. The roof of the house was like a planing machine, having two shot-projecting wheels in this roof. The castings were placed inside the cabinet and the roof travelled backwards and forwards over them. The castings were being cleaned at the rate of one every two minutes. A machine like that was badly wanted, but one could not afford to have one that did only one type of casting, so that he collaborated with the makers, and the solution was finally a large rotary table, 19 ft. in diameter, with two shot-impeller wheels in the roof.

A further development in cleaning castings was the hydro-blast, which had a combined jet of water and sand. For separating the sand from the water a form of pump was used which was a classifier, and, with the aid of this, several American founders were hoping to reclaim their sand. The fine sand would be thrown away and the clean sand retained for use.

He thought Mr. Deschamps' results from feeding the aluminium wire into the casting were very interesting, and he should say he was getting a controlled grain size, which affected his Izod results.

Mr. Deschamps, speaking on the question of specifications, said that, at the present time, steelfounders were all doing very well. Until a couple of months ago they could not cope with the volume of orders. That state of affairs, however, would not last for ever, and he visualised the time when they would have to fight once again for their existence. The talk of buying out redundant capacity would be revived in a few years' time. It seemed that the best way to rationalise the steelfoundry industry was to eliminate the inefficient and concentrate the work available in the really efficient units. He thought that it was desirable to make specifications so difficult that only the fittest would survive, for the benefit of the industry as a whole.

With regard to chemical composition, there was one case where they must admit there was a distinct right to specify carbon and manganese, and that was where castings were to be subjected to a hardening process. In this case, buyers had the right to insist on the carbon content because it was essential for carrying out the particular process.

It seemed to him that, though the water-blast might be something of a nuisance, yet anything which could successfully replace that dreadful process of shot-firing should be adopted.

In connection with the experiments with aluminium additions, he had encountered an alloy of 94 per cent. aluminium and 4 per cent. copper which was very successful. This alloy did not, however, lend itself to the process of wire-feeding, and it was impossible to distribute this alloy with the same uniformity as if it were stranded. He tried to overcome this heterogeneity by winding thin copper wire round aluminium wire, but the experiment was not successful.

Izod Test Variations in Castings

Dr. P. Longmuir observed that all steelfounders would appreciate the author's remarks on analysis. Mr. Deschamp had mentioned a drastically over-oxidised steel. They could get down to 0.02 per cent. sulphur and phosphorus, but they still wondered whether that excessive oxidation resulted in the retention of oxide in the finished steel.

With regard to Izod tests, very few founders welcomed them, but such tests were bound to come in time. Whether in a forged or a cast steel, they all knew that they could meet the normal specification as to yield, maximum stress, elongation, and reduction of area with regularity, but they also knew that they could not secure that same regularity with the Izod test. He would welcome comparative figures of forgings and castings. The author had said that it was possible, by suitable heat-treatment, to get a casting to give the same ordinary tests as a forging. Was it possible to guarantee a casting giving the same Izod test results with regularity as were obtained from forgings?

Comparison with Forgings

Mr. Deschamps regretted that he was not quite conversant with forgings, but he had seen several specifications with a tensile strength of 35 to 40 tons, to which many plain carbon steel forgings were made for the motor-car industry, an Izod figure of 30 to 34 lbs. being required. He contended that, with proper means and without having to resort to heat-treatment, the Izod figure could be raised to 30 to 34 lbs. He would not say that steel castings would ever be as reliable as steel forgings, because they always involved hazards which did not arise with forgings.

Specificational Difficulties

Mr. T. R. Walker said that, with regard to the question of chemical analysis, he thought it was a fact that quite a number of steel castings were made without any chemical analysis specification at all. In his experience the range of analysis of those that were specified was particularly wide, and he saw no reason for abolishing them, because they were so easy to meet; yet they did give a certain measure of control by the purchaser. Quite apart from that, even if the purchaser did not specify chemical analysis, the foundrymen always specified an analysis to the steelmaker, and where there was a chemical specification, that was, 99 times out of 100 narrower than the official specification, the furnaceman found no difficulty in meeting it. Sulphur and phosphorus in most specifications for castings was about 0.06 per cent. maximum. With harder steels and more difficult tests, a high sulphur and phosphorus content made all the difference between meeting the specification and missing it.

They had heard much about the Izod test, and also about making a test from a casting equal to that from a forging. He would say that a customer should not expect the same from a casting as he did from a forging or a drop stamping. He did not pay as much for the casting. If the casting was not good enough, he should buy a forging, which was better for both the maker and the user.

The castings already made by all reputable firms were properly annealed and normalised, or annealed, and the Izod figure for soft castings ran very often between 30 and 50 lbs. Those were very good figures, and he did not think there was anything wrong with the impact value of ordinary soft carbon steel castings as made in Sheffield and elsewhere, because there were thousands of such castings made and used in railway work, for example, automatic couplers, etc., which all had to stand a considerable amount of shock.

He noticed that Mr. Deschamps had mentioned that the Izod test had been introduced into some foreign specification for wheel centres. He thought it was a fact that in this country no wheel had ever failed in service through anything going wrong at the wheel centre, even though it had not been subjected to an Izod test; it was good enough for the job even under the punishment it received. The author had also said that by the use of aluminium he could increase the Izod figure by two or three times. That depended on what value they started with; if they started with an Izod figure of 40 and multiplied it by three, then the maximum limit of the machine, which was only 120, was reached.

Synthetic Sands

A good deal of progress had been made recently in the use of synthetic sands, employing silica sand and clay. The green strength and dry strength obtained from such a mixture depended upon the clay used and also the shape and nature of the grains. With a rounded silica sand, one did not get as good a strength figure as with a sand having an irregular surface. If high permeability was wanted, one had to use round grains, because angular grains diminished the permeability. The green strength from such mixtures depended upon the water content. The dry strength, which with low water content was very little better than the green strength, rose steadily as the water content in the dry state was increased. Foundrymen could exercise discretion as to the amount of water they were using; that depended whether they were working in green sand or dry sand. If they worked with dry sand, they could afford to increase the water and increase the dry strength considerably. Bentonite was the most efficient of all the clays at the moment; it went distinctly further than the other clays, and had the advantage of retaining the plasticity up to a higher temperature than other clays, and they could reclaim a much larger proportion of the sand in the mixture.

Mr. Deschamps said it was a common thing to get up to 30 or 35 permeability.

Mr. Walker said the effect of the added aluminium was to refine the grain size. That was satisfactory for working on converter steel. He had examined some Sheffield-made castings and they were initially fairly fine-grained, and Sheffield makers would not obtain the same effect as the author did because they were working with different material, which had a higher Izod and a finer grain initially.

Dr. Dadswell said he did not see how the measure of permeability could indicate the refractoriness of a moulding material.

Refractoriness

Mr. Walker said it depended on what was meant by refractoriness. If one was talking about sintering it was a surface phenomenon. Sintering started more readily with small grains than with large grains, but it was not a question of refractoriness as such; the melting point remained the same.

Mr. Deschamps said the determination of the actual refractoriness was a lengthy process, whereas it was a matter of minutes to determine permeability.

Mr. Walker said he did not agree with that statement.

Mr. Deschamps replied that if one had a sand of 10 lbs. compression, the higher the permeability for the same compressive strength the better the tensile strength of the castings. He preferred to deal with 10 lbs. per sq in. than a 60 permeability figure.

Mr. Walker said that if one increased permeability one did it by adding to the silica sand, and that was increasing the silica content. He could obtain successful results with a wide range of permeability.

Dr. Dadswell thought the importance of permeability was often exaggerated, although in green sand it was very important.

The Branch-President said that the author had admitted that the intention of his Paper was definitely to be provocative, and it had worked out exactly as the author hoped; they had had a most illuminating and, he thought, instructive discussion.

Vote of Thanks

Mr. J. Roxburgh said although he had not contributed to the discussion he welcomed the opportunity of proposing a vote of thanks to Mr. Deschamps. He had outlined certain aspects of steelfoundry practice and then had dealt with the developments, and also the possible developments, making his remarks provocative; and no doubt he had succeeded, as many other lecturers did, in learning something as well as imparting knowledge to the audience.

Mr. C. D. Pollard, seconding the vote of thanks, said they should admire Mr. Deschamps and thank him, too, for his advocacy of the survival of the fittest. He thought there was very great credit due to him for sticking to his point regarding the stiffening of specifications for steel castings. They all knew that Mr. Deschamps had been pressing for this for some time, and he wished him success in his effort.

Banded Structure in Cast Materials

(*Concluded from page* 308.)

The reaction product of the mutually encountering waves is also present. In addition, there is the peculiarity of the metallic substratum and the difference in the diffusion constants. The following example will show what occurs when the waves meet. The decarburisation of malleable cast iron mainly proceeds in accordance with the gas equilibria developed by Schenk and collaborators. There is thus a counter-flow of gases summarily represented in its decarburisation effect as a hyperbolic carbon drop (Fig. 13, curve *a*) seen from the core towards the edge of the casting. A migration of sulphur must occur simultaneously, however, especially in circumstances favourable to peeling. The hydrogen sulphide found experimentally in the pots reacts as follows with the outer skin of the casting: $Fe + H_2S = FeS + H_2$. The ferrous sulphide formed accumulates on the outer skin and layers following it. At the same time, oxygen arrives on the outer zone and burns the sulphur of the ferrous sulphide partly to sulphur dioxide. Since the diffusion constant of oxygen or ferrous oxide is smaller than that of the sulphur in hydrogen sulphide or ferrous sulphide, which is proved by the position of the sulphide ring in front of the oxide inclusions, a pearlite maximum is formed in the sulphide ring corresponding to the stability conditions of the iron carbide, or referred to Schenk's first equation: $2\,CO = CO_2 + C$, it means that the latter proceeds in the direction for carburisation. A scheme of the individual processes is shown in further detail in Fig. 13.

In annealed cast iron and "orange-peeled" malleable cast iron, structure formations of this kind which owe their origin to diffusion streams directed from the outside inwardly and conversely are frequently found. These banded structures, however, are also characterised by the nature of the reaction products, and therefore a study of the limits of stability is particularly important. Above all, however, it is necessary to ascertain to what extent these bands can be produced experimentally and in what manner they depend upon the conditions of cooling. Further investigations are in progress.

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Some Points on Non-Ferrous Foundry Practice

By A. PHILLIPS

(*Concluded from page* 292.)

BRASSES, BRONZES AND GUNMETAL

As there is such a wide variety of alloys which enter into this category, only general principles can be dealt with.

Melting

The conditions when melting brasses, bronzes and gunmetal are different from copper. In copper there are soluble oxides, but as both tin and zinc reduce copper oxide, the insoluble oxides of tin or zinc are formed. Zinc oxide is very light and quickly rises to the surface of the melt, where it can be skimmed off. Tin oxide, which is nearly as heavy as the metal, does not readily rise to the surface, and is therefore more difficult to eliminate. Frequent discussions have taken place regarding the use of phosphorus, a popular deoxidiser for bronze, to reduce tin oxide. It is just as essential to prevent oxide finding its way into the casting by mechanical as well as chemical means. The first precaution is to insist that the scum is properly skimmed off the melt, and secondly to ensure that the runners are so formed and placed to prevent oxide or scum entering the mould.

Runners

The gating of brass, bronze and gunmetal castings is a subject that has a very wide discussion. Gating castings presents problems requiring careful thought and knowledge of the alloy used. For instance, the red brasses or bronzes are gated differently from aluminium alloys or manganese bronzes, and as this subject is large and would require a vast amount of detailed description, only two different methods will be indicated. Fig. 14 shows two castings with their moulds; the one on the right is poured in Admiralty gunmetal (88 : 10 : 2), and that on the left is a slip-ring alloy. Here are two totally different types of runners, but in all cases of runners, the down runner is always made sufficiently large to allow a good stream of metal from the ladle to enter it. This allows the temperature to be maintained in that portion of the runner, and enables the supply of metal at the correct temperature through the ingates. Down runners are made much larger than what would be the practice in cast iron.

Practically every non-ferrous foundryman has made castings in Admiralty gunmetal (88 : 10 : 2), and has experienced difficulty in meeting the specified physical properties. Table II sets out the different test results obtained from this alloy which, when examined, showed the presence of oxides. These bars were poured from one crucible of metal. The A bar, poured at a high temperature, would pass the specification, and from this it can probably be said that oxidised metal is better poured at a higher temperature than is the usual practice. If, however, castings are made with metal in this condition, those poured at the latter part of the pour would be totally unsuitable and on machining would show up various defects.

Table II.—*Physical Tests on Gunmetal* (88 : 10 : 2) *Poured at Different Temperatures from One Crucible of Metal.*

Bar.	Pouring temp. Deg. C.	Y.P. Tons per sq. in.	U.T.S. Tons per sq. in.	E. Per cent.	R.A. Per cent.
A ..	1,200	9.0	17.4	18.6	21.0
B ..	1,160	9.5	12.2	3.4	4.0
C ..	1,100	8.9	11.0	4.6	5.0

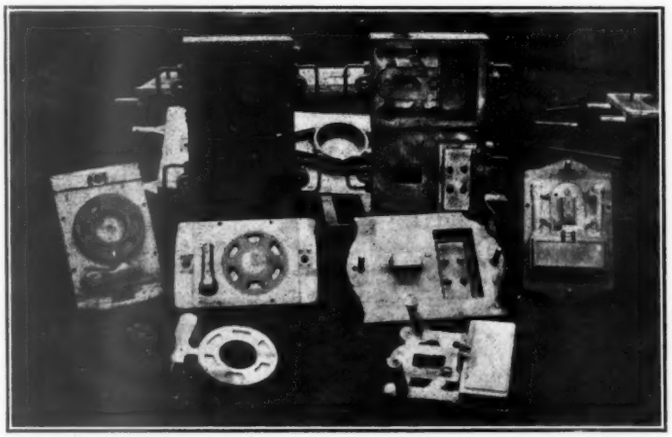


Fig. 14.—Castings in A.G.M. and Slip-Ring Alloy, together with Patterns and Moulds.

Fig. 16.—Permanent Cast-Iron Die Assembled.

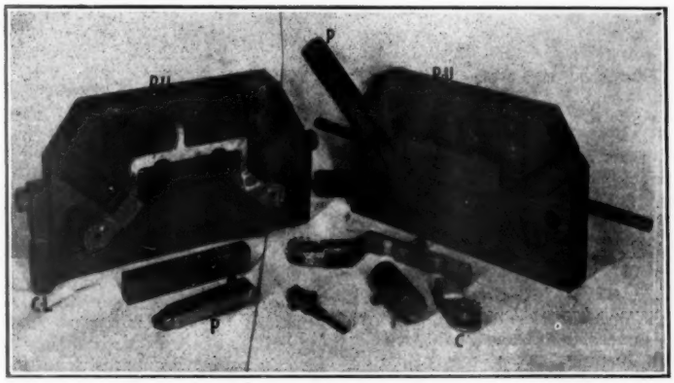


Fig. 15.—Permanent Cast-Iron Die, with Aluminium-Bronze Die-Casting and Different Plugs.

Pouring Temperatures

It is very important that pyrometers be used constantly. The regular use of a reliable pyrometer in all non-ferrous foundries is a practice which is to be strongly commended, as by this means one phase of non-ferrous foundry practice can be standardised and valuable data obtained. One point with regard to the fixing of casting temperature limits perhaps deserves to be mentioned. The generally prevalent idea is that the heavier the section of the casting the lower the casting temperature should be. This is not always strictly true, as a very important factor is being neglected if only this aspect is considered, and that is, the distance the metal has to travel to the farthest point of the mould. It should be realised that once the metal has entered the mould the temperature falls with great rapidity, so that by the time it has travelled a short distance the temperature is very different from that of the metal in the pot.

Table III.—*Range and Average Pouring Temperatures for Various Types of Metals and Alloys.*

Type of casting.	Temp. range. Deg. C.	Average. Deg. C.
Copper	1,150–1,280	1,160
A.G.M.	1,090–1,250	1,160
Phosphor bronze..	950–1,160	1,030*
Mn-bronze ..	990–1,080	1,030
Al-silicon (7½ per cent.)	600– 720	620

* According to phosphor-tin content.

Thus, in fixing the casting temperature, this very important factor must be taken into consideration. The casting temperatures used vary according to type, size and section of casting. They are set out in Table III.

Die-Castings

Another branch of non-ferrous foundry work is die-castings. This method of producing castings outside the sand-cast field has had a rapid growth during the last few years, and as it should form the subject for a complete Paper, only a very brief description of it will be given. The term "die-casting" covers the production of castings in metallic moulds with either metal or destructible cores. The moulds may be filled by gravity, when the resultant castings are known as permanent-mould castings, or the metal can be forced into a metallic mould by mechanical pressure whilst the metal is in the molten or semi-plastic state. The castings thus produced are usually termed pressure die-castings. Pressure die-castings may be sub-divided into low-pressure and high-pressure castings. The low melting-point alloys are usually used with the low-pressure machines, whilst brass and aluminium alloys are used in the high-pressure machines. Fig. 15 shows the cast-iron metal mould for a permanent-mould casting. The casting, which is made in an aluminium-bronze alloy, can be seen at C. The steel plugs for the various holes and faces are shown at P, and the runner at R.U. The clamps for holding the die together during the pouring operation are indicated by CL. The assembled mould is shown in Fig. 16. A man can produce approximately 20 castings per hour from such a die, and the finish on the castings is excellent. Castings made in permanent moulds are invariably poured from the top. In Fig. 17 is shown a casting made in a permanent mould, PM, and the same design made in a plastic pressure die machine DM. Both these castings are made in brass, yet they are poured in different ways. Fig. 18 shows a section of a plunger machine, of which there are various types. The use of this type of machine is limited to alloys of a low melting-point. As the metal is forced through the nozzle by means of the plunger, it can be readily seen that the wear and attack of the surface of the plunger with a high melting-point alloy would soon make it stick. Castings with a tin, lead or zinc base are usually made with this machine. If castings made in zinc-base alloys are to be exposed to atmospheric corrosion, it is most desirable that zinc of 99.99 per cent. purity be used.

Fig. 19 shows a high-pressure machine for the production of castings in brass or aluminium. The metal, which is placed in the chamber C in a plastic state, is forced into the steel die D by the plunger P, at a pressure varying from 500 to 1,750 lbs. per sq. in. The opening of the die and the withdrawal of the plugs are done by mechanical means, whereas with the permanent mould all the plugs are usually withdrawn by hand.

The die-casting process, like any other process, has its limitations, and it is advisable to consult an up-to-date die-casting concern before attempting to design die-castings, as they have all the necessary data of the various alloys together with their limitations of manufacture.

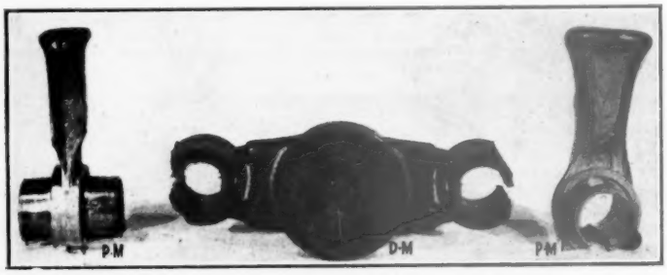


Fig. 17.—Methods of Running Pressure-Cast and Permanent-Mould Die-Castings.

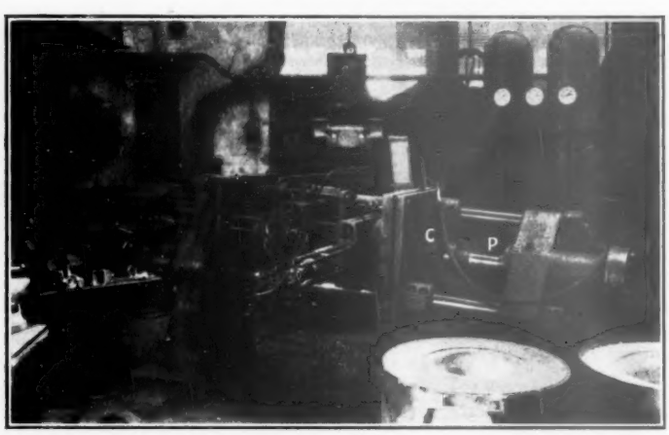


Fig. 19.—High-Pressure Plastic Die-Casting Machine.

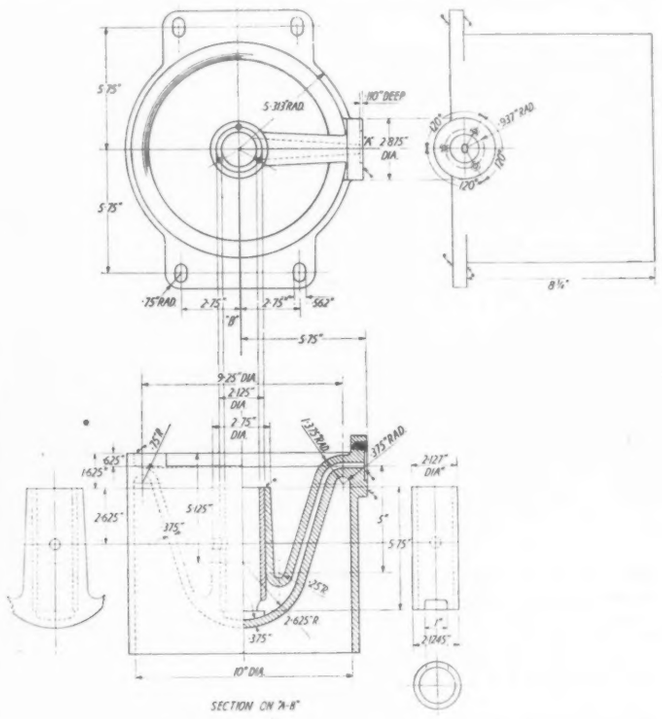


Fig. 18.—Plunger Type of Die-Casting Machine.

The author wishes to thank the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, for permission to publish this Paper, and especially to Mr. W. Jolley, superintendent of foundries and patternshop, for his advice in its preparation.

DISCUSSION

Following the presentation of Mr. Phillip's Paper to the Lancashire Branch of the Institute of British Foundrymen, a vote of thanks to the author was proposed by Mr. Norman Cook and seconded by Mr. E. J. L. Howard. The vote of thanks was carried unanimously.

Deoxidisers and Electrical Conductivity

Mr. Howard, who opened the discussion, said he had had extensive experience of copper castings, particularly for electrical purposes, and he had adopted identical methods to those which had been mentioned. As had been pointed out by the lecturer, the usual deoxidisers could not be used, in view of the conductivity which was demanded. A few years ago a method of deoxidising copper had been introduced which consisted of passing nitrogen through the molten metal. It was fairly successful, but he was unaware to what extent it was used. Copper castings in which a high conductivity was not required could be successfully produced by the addition of about ½ per cent. tin, and then deoxidising with phosphor-copper.

Mr. Phillips said that the use of nitrogen, referred to by Mr. Howard, had been practised in some cases, but personally he did not think it was a commercial proposition. It was not easily manipulated in the foundry as was the silicon-copper method.

Crankshaft Wear due to Leaded-Bronze Bearings

The Chairman said he had been troubled by grooves being cut into the crankshaft of leaded-bronze bearings, and so wearing it out. Could a remedy be suggested? He was unable to say what the composition was.

Mr. Phillips observed that there was a great variety of leaded-bronze, and, unless the product was examined, it was hard to give a reply to the question. The higher lead contents resulted in a softer material and less liability to scour shafts. In a copper-lead-bronze, lead segregation occurred unless some addition, such as a small percentage of nickel, was made to assist even dispersion. Pouring temperature effects were also experienced with leaded-bronze, and if the pouring temperature were too high, there was a liability to get the larger portion of the lead at the bottom of the casting. Directly opposite that was a phosphor-bronze; cast at high temperature, the tin was forced out at the top.

Making Slip-Ring Castings

Replying to Mr. Brown, who asked for further details regarding the slip ring referred to in the Paper, Mr. Phillips said that this was not 88-10-2 gunmetal, but a slip ring alloy which contained lead. For that particular size, and for ease in quantity-production, the ring had been placed on a board, but if it were larger, it would be run from the inside, and chills placed

on the outside; a bridge runner would be used to break the flow of the metal. For a small ring there was a large feeding down-runner, and the runner on the joint went past the in-runner on the casting, which allowed any scum to go past, and only the clean metal to enter the mould. As had been stated, chills were placed round the outer periphery, these chills being ground in one direction to allow any gas which collected on the faces to escape up the furrows or grooves. It was important for the chills to be ground in the same direction as the flow of the metal, especially when chilling non-ferrous castings.

Manganese-Bronze Liners

In regard to the manganese-bronze liner, there was a horn runner fed from a channel on the middle joint of the casting; it did not come in with just a point, and thereby create a squirt, but extended downwards in length. A little slot was cut down from the underside to ensure a gradual rise of the metal, thus eliminating splashing or turbulence.

Sufficient experiments had not been carried out regarding gases absorbed in moulds to enable any definite statements to be made. Immediately an infallible guide for detecting gas faults could be found, trouble experienced with gases would be overcome. Gases absorbed in the melt could be caused by steam from moisture in the mould. A metal like copper might absorb water vapour, and if copper was being run into a mould in which moisture was present, this formed a gas which would be readily absorbed, and consequently the casting would give trouble when machined. A point which should always be borne in mind when deoxidisers or degasifiers were being added to an alloy was whether they were being added to remove the gas, or to help the metal to absorb the gas. For example, a certain quantity of salt could be dissolved in a glassful of water, but something could be added which would precipitate the salt; that could also be done with molten metal to precipitate or liberate gas. Alternatively, an addition could be made to the water to enable it to take more salt into solution. Was the same thing being done to the alloy to assist the metal to absorb or remove the gases? These were points which had to be thrashed out by foundrymen by experiments.

Live-Loads and Inter-Crystalline Corrosion

Mr. Reynolds asked if the lecturer had ever used phosphor-copper as a deoxidiser in the case of high-conductivity copper castings; if so, what were his conclusions as compared with silicon-copper? The firm with which the speaker was connected used phosphor-copper as it usually gave a more fluid metal, and practically no difficulty was experienced with conductivity providing the requisite amount was used.

Personally, he admired the large boxed-shaped silicon-aluminium casting, and asked what kind of core was used—whether it was an oil-sand core, or a naturally-bonded one. Did the lecturer ever find it necessary to use a deoxidiser for manganese-bronze, and had he any experience of its behaviour under live-load conditions, that was, electrical current conditions, on exposure to atmosphere? Many alloys, particularly light alloys, had given trouble under atmospheric conditions with live-load by inter-crystalline corrosion, caused usually through the copper-aluminium compound which formed with even 2 per cent. copper in aluminium, and which sometimes led to complete disintegration of the alloy. As there was aluminium in manganese-bronze, he would be interested to know of any experience the lecturer had had of its behaviour under similar conditions. The action was tantamount to a galvanic action caused by the difference of contraction between the two metals, copper and aluminium.

Had the lecturer any experience—experimental or in general production—of making copper castings by either the gravity or pressure-die methods?

Silicon-Copper Advocated

Mr. Phillips replied that he had had a little experience with the use of phosphor-copper, barium carbide, and several other elements for reducing gas effects in high-conductivity copper castings. He had found, however, that to produce castings having over 80 per cent. conductivity, silicon-copper was the most satisfactory. With phosphor-copper the reduction of the conductivity was too severe, because of the quantity that had to be used, and there was more trouble from gas effect during machining than there was with silicon-copper.

The casting referred to by Mr. Reynolds was made with an ordinary sand core, which was made very weak. With aluminium alloys, cores had to be weak, because there was not the same chance of the core gases escaping as there was with higher temperature alloys like bronze or cast iron. When making an aluminium alloy U-shaped casting, cast with the flange up, the vents should always be liberated from the bottom of the U-face core so that the gases could get away very quickly from the bottom faces. Aluminium alloys quickly solidified, and gases caused trouble if they could not escape freely and rapidly. Oil-sand cores were used very extensively on a large casting similar to the one referred to, and to the same extent as they were used in cast iron, or any other alloy.

As to fluxes for manganese-bronze, and the use of deoxidisers, there was a very large amount of zinc present which was self-acting as a deoxidiser. He had no experience of live-loads in atmosphere with manganese-bronze. Aluminium alloys disintegrated more readily under live-loads. He could not give a great deal of information on live-loads at the time, but he would reply to any questioner in writing.

Copper Die-Castings

No appreciable amount of success had been experienced with high-conductivity copper die-castings. As was the case with phosphor-bronze die-castings, trouble was caused by gas. An examination of the skin of a permanent-mould gravity die-casting showed it to be full of holes, as though it had been poured in a cold die; moreover, with copper large shrinkage holes caused difficulty.

Casting Temperatures of Si-Al Alloys

Mr. A. Hopwood asked if the maximum casting temperature of 720 deg. C. for silicon-aluminium covered the high-silicon percentages, or whether it was confined to the low-silicon alloys. He also asked what types of castings were cast at that temperature. With regard to the ease with which scum formed in silicon alloys, he would like to know more regarding the casting temperature, and the effect it had on the formation of scum from, say, the poor formation of runners and gates. From what little experience he had had, the castings showed more dross formation when cast at the lower temperatures than the higher range. Mr. Hopwood said he was referring to 13 per cent. silicon alloy.

Casting Temperature and Runner Size

Mr. Phillips said that when he had spoken about the maximum pouring temperature of 720 deg. C., he implied castings of normal size, because aluminium-silicon alloys were similar to phosphor-bronzes. In a phosphor-bronze they had a definite pouring temperature, and if the metal reached a higher temperature, trouble would result. Therefore, the size of the runner was increased to assist in filling the casting, and the same process was used in regard to aluminium-silicon alloys, irrespective of whether the silicon was 13 per cent., 12 per cent., 10½ per cent. or 7½ per cent. The size of the runner was increased so that a pouring temperature as near to the minimum as possible was obtained.

Regarding scum in aluminium castings, the castings were invariably poured at the bottom, and providing there was no dampness or hardness round the runner, and the temperature was kept at about 720 deg. C. or below, he did not think any trouble would occur. It might arise with higher temperatures.

Alkaline Metals and Pinholing

Mr. Hopwood had been told that if alkalis were present in aluminium alloys there was no pinhole or gas effect. From his own observations, he did not agree with that. Had Mr. Phillips any data on the subject? Also, what trouble occurred when casting silicon alloys at too high temperatures?

Experiments with Super-heated Light Alloys

Mr. Phillips said that if a bar were cast at too high a temperature there would be gas effects in the centre of the bar, and a much coarser grain structure. The opinion was once held that if an aluminium was melted at over 900 deg. C. the alloy would be spoiled. From his own experience, he could say that these alloys had been melted at 1,060 deg. C. They were allowed to cool, and in the cooling stage test-bars were made, fractured and examined for gas effect. As soon as it was found that the structure had no gas effect, then the men could start pouring.

He disagreed with the statement that if there were an alkali metal in aluminium alloys there would not be pinholing. His experience over a number of years was that most definitely there could be pinholing when alkali metals were in the aluminium-silicon alloy. Pinholing resulted from various conditions, one being modification at too low a temperature; the pinholing was due to the gas effect. Another condition was pouring a casting at too high a temperature, as there was gas in solution. If the runner could be adjusted, and the pouring temperature be adapted to approach the minimum, pinholing would be avoided. One method in which pinholing was not prevalent was to melt the metal and bring it to a very high temperature, probably 1,060 or 1,070 deg. C., and then to modify it with the material which was used at that temperature, and allow it to cool down slowly. Samples were taken in the cooling stage, which would probably occupy a period of about two hours with a cast of metal of 600 lbs. When it was found that there were no gas effects in the bar, the castings could be poured. It was thus probably at the right temperature, and he did not think much trouble would be experienced with pinholing. Damp moulds, hard moulds and cores would also give the pinholing effect.

Beryllium-Copper Castings

Mr. E. Longden asked if Mr. Phillips had ever introduced beryllium into copper. It was a very expensive metal, but remarkable results had been achieved with 2 per cent., up to 70 tons tensile strength having been obtained. With copper tuyeres there was not the same difficulty with electrical conductivity, but they were certainly difficult to cast. In introducing phosphorus one had to be careful to use just as much as would be practically eliminated in the deoxidising of the copper. It was not always possible, however, to know how much phosphorus to add because of the absorption of cuprous oxide in the metal. With copper mixtures, the purest of copper alloy must initially be used to avoid having any need to deoxidise.

Modification Conditions

Mr. Phillips had not given much information with regard to the modification of silicon alloys. The time of modification was very important, because of the vital changes which took place during the modification period. If the time of modification was not sufficient, they had poor and insufficient refining, or if the period of modification was too long, they had a reversion to the unmodified conditions. The lecturer had stated that cores were made in dry sand; surely they were in green sand, not dry sand? Aluminium castings were endangered if made in oil sand, since contraction was too rapid for the expulsion

of the oil from the core sand, unless the castings were simple and massive.

Mr. Phillips replied that dry sand was used, but oil-sand cores could be used. Many actually were used in aluminium alloy work, but these were made of a very weak and friable nature, so that there was no question of the burning of the gas having time to cause any ill-effects. He had not had experience of beryllium in copper, but he gathered that a 2 per cent. addition certainly would produce up to 70 tons tensile strength. The proposition was very expensive, but most valuable for the foundryman who wanted a very high strength copper. The addition of phosphorus to copper in some instances resembled the addition of phosphor-tin to bronze. Tin sweat was created when a phosphor-bronze was cast at a higher temperature than was normal. If, however, the same percentage of tin and copper was cast at the same temperature, tin sweat did not result. Therefore, tin sweat could be traced definitely to the action of the phosphorus in the metal. When cast iron was cast in a chill of, say, 2½ in. diameter, there was a squeezing out of the phosphide eutectic in the centre, which occurred when there was a partial solidification of the casting. The squeezing out of tin in a phosphor-bronze occurred in a similar manner. Phosphor-copper added to molten copper for high-conductivity castings lowered the conductivity more than silicon-copper. Better results were obtained by using silicon-copper than phosphor-copper, for the reason that phosphorus had such a delayed action when the material was solidifying; it was far better to have something which had not that action, if a sound casting was required for machining.

Modifying Al-Si Alloys

The first of several methods of modifying aluminium-silicon alloys was the fluoride method, which consisted in throwing potassium fluoride salts on the top of the molten metal at a temperature of approximately 900 deg., and allowing the action to take place. In a second method, metallic sodium was used, and a small quantity was put in a metal cup and plunged into the metal; this was sufficient to alter a coarse structure to one which gave an excellent bend test. Additionally, sodium hydroxide could be added in a similar way to potassium fluoride, or again sodium carbonate—a later method requiring a higher temperature, the metal having to be heated up to about 1,060 deg. C. When the metal was covered with the flux there was a violent reaction, and a burning of the sodium. This reaction gave the metal the essential fine-grained structure illustrated by one of the micro structures of the Paper.

Mr. Longden had referred to reversion. If the alloy was held too long after it had been modified it would revert to an unmodified structure. Immediately the correct temperature was attained the casting should be poured.

Use of Charcoal in Crucible Practice

Mr. A. Jackson said that the two essentials in the non-ferrous foundry were correct melting and temperature control. The method of covering the metal with charcoal was very old. He was recently interested to learn there were three ways in which charcoal could be introduced. It might be preferable to put the charcoal in the bottom of the crucible, and when the metal above melted, it would pass through the charcoal in the same way that the iron passed through the coke and slag in the cupola. The second method was to sandwich it centrally, and the third was to leave the charcoal until all the metal was in the crucible. Of the three methods, could Mr. Phillips say which was the best? The first method had been strongly recommended for manganese-bronze, but was found to be unsuitable for aluminium-bronze.

Recently, he knew of a case where a gunmetal bush, 6 in. long, 3½ in. in diameter, and ½ in. thick, had been returned. It was made in two halves, but he could not say how it was run, because the ends had been ground. A curious feature was that a wedge-shaped part of the casting was of iron. This part was the full thickness of the casting, 1 in. wide at the end, 3 in. in length, and tapering to a point. The iron appeared to have segregated, yet the bond with the gunmetal was perfect. He imagined that the mould had been cast tilted and the iron had separated out when the casting was poured. Was this a natural phenomenon, when too much iron was present in gunmetal?

Dangers from Wrong Use of Charcoal

Mr. Phillips said charcoal was not used by itself for a covering flux in manganese-bronze; in the foundry with which he was associated, charcoal mixed with borax, salt and ground glass was used, so as to form a slag and a covering for the top of the bronze. For copper, as he had previously said, charcoal should not be put at the bottom of a highly-heated crucible. Charcoal was able to absorb about 10 per cent. of moisture, which would probably be given off as water vapour, and the metal would absorb that vapour. When melting in a crucible, it was best to place the charcoal on the top of the metal.

Iron in Gunmetal

Regarding the question of a wedge of iron in the gunmetal castings, this was quite easily done. If there were some iron in the scrap when the metal was being re-melted, it would not dissolve in the brass or the gunmetal; it would remain undissolved and would form the wedge. He had known cases where bolts had been made from scrap brass. The bolts looked satisfactory, but one or two snapped like carrots, because beneath the outside skin of brass there was a core of iron in the centre. Much difficulty was experienced in mixing iron and brass, and the iron was usually added as ferro-zinc or ferro-hardener; otherwise it would not go into the solution, but would remain as a separate metal.

Referring to the graph (Fig. 3), Mr. Phillips gave the following explanation, using as an example the following:—

3.5 per cent.	Mn	Mn	÷ 2	—	1.75
1.0 ,,	Fe	Fe		—	1.00
2.5 ,,	Al	Al	× 2	—	5.00
35.0 ,,	Zn	Zn		—	35.00
Remainder Cu		Total			42.75 Zn equivalent

From the graph this gave 42 tons ultimate tensile strength and 28 per cent. elongation, and just over 30 per cent. alpha structure. If the tonnage be divided by 0.22, it gave approximately 190, which gave the Brinell number. The Brinell hardness increased progressively in a manner similar to the tensile strength.

French Foundry Technical Association

At the annual general meeting of the French Foundry Technical Association, held last week in Paris, the following officers were elected for the forthcoming session.

President.—Mr. Henri Sandre (chairman and managing director, Sté Métallurgique du Périgord).

Senior Vice-President.—Mr. Henry Strube (President of the French Non-Ferrous Foundry Employers' Federation).

Vice-Presidents.—Prof. P. Chevenard (research manager of the Commentry, Fourchambault, Decazeville concern, and Professor at the Foundry High School); Jean Derdinger (Past-President of the Non-Ferrous Foundry Employers' Federation); Charles Koehler (general secretary of the Foundry Employers' Federation); Jean Lobstein (managing director of the Lobstein Company and President of the Paris Ironfounders' Employers' Federation); Roger R. Meyer (director of the Products Métallurgiques Company); Léon Montupet (managing director, Montupet Foundry Company), and Augustin

(*Concluded at foot of next column.*)

Random Shots

Life is just one exhibition after another, apparently, the one now in the news being the Ideal Home Exhibition. For the foundryman coming up to London for a few days at Easter it is just another opportunity to see the castings, *en masse*, which are such a myth at foundry exhibitions. For his wife it is just another opportunity of finding a thousand new ways of spending the hard-earned cash.

* * *

One can hardly fail to remark, at this exhibition, how most domestic castings these days are decked out in the gayest of apparel. Vitreous enamelling of beautiful colouring and gleaming surface greets the visitor everywhere. Aluminium, Monel and stainless steel stand unadorned, a delight to the eye in themselves.

* * *

At the same time, that old truism, "People in glass houses shouldn't throw stones," takes on a new meaning with the introduction of the "All glass house." The sun-worshipper's delight, it is said to be, but one is constrained to wonder if it is still their delight when the sun fails to shine, for the greyness of the glass bricks only serves to intensify the greyness of bleak winter days, and "Marksman," for one, craves for warmer colourings.

* * *

If spending a day at an exhibition during Easter is too much of a punishment, there is the alternative of going to Blackpool, just to stand and stare at the sands, for "What is this life," saith the poet, "if full of care, we have no time to stand and stare?" And perhaps to muse upon the thought that to some sand means work, to others it means play, and to a few it means just the length of time it takes to boil an egg.

* * *

Does a moulder make sand pies or does he not? Mr. J. F. Kayser, who is chief metallurgist of the Gillette firm, tells a good story which proves that one, at least, would scorn to stoop to so infantile a sport. Playing with his small son on the sands one day, he amused himself by "sand-slinging" the sand into the bucket in quite a professional manner. A hefty looking man stood watching silently for a few moments. At last he shot out a question, "Moulder?"

"Aye, moulder," said Mr. Kayser mischievously.

"Thought so," came the reply from the strong, silent man, who passed on without another word.

* * *

Two men were once boasting about the regiment in which they had served during the war.

"Finest regiment on record," said one. "'Shun!' said the sergeant-major, and we stood to attention as one man. 'Form fours' said the sergeant-major, and we did it as one man. 'Right turn' said the sergeant-major. Again as one man. 'Quick march,' and every time just like one man." "Here! hold on a minute," interrupted the other. "In my regiment it went 'Shun!'—as one man. 'Form fours'—one man. 'Right turn'—one man. 'Quick march,' and forward we went. Left—jingle, Right—jingle, Left—jingle."

"What the blazes do you mean by all this jingle stuff," asked the first in disgust.

"Oh, them? Medals!"

"Marksman."

(*Concluded from previous column.*)

Rousseau (President of the Foundry Mutual Benefit Society and manager of "Revue de Fonderie Moderne").

Honorary General Secretary.—Mr. Charles Dennery.

Honorary Treasurer.—Mr. D. Waels.

The foreign Vice-Presidents remain unchanged.

Life of Ingot Moulds

USERS' AND MANUFACTURERS' VIEWS AT SHEFFIELD

As reported in the JOURNAL last week, a joint meeting of the Sheffield Metallurgical Association, the Sheffield Branch of the Institute of British Foundrymen and members of the Iron and Steel Institute was held in Sheffield recently to discuss the First Report of the Ingot Moulds Sub-Committee, which forms Section VI of the Seventh Report on the Heterogeneity of Steel Ingots. The Report was introduced by Mr. R. H. Myers (chairman of the Sub-Committee) and Mr. J. G. Pearce, and the remarks of these two gentlemen were printed in last week's issue. Below we give a report of the discussion which followed.

Mould Economy

MR. SMITH (Steel, Peech & Tozer) referred to the investigation of his colleague, Mr. Bacon, which had now extended over six years, and indicated what that investigation had meant to Steel, Peech & Tozer. When Mr. Bacon started that work in 1932, they were using about 29 lbs. of mould metal per ton of steel for what they called their standard mould, which was then a 21½-in. open-top mould. That figure had now been reduced to 15¼ lbs. and the saving to the Templeborough melting shop alone amounted to roughly £300 per week. Thus, the reward for the work that Mr. Bacon had done had been an ample one. It might also interest the meeting to know that long before Mr. Bacon's department or plant had got into its stride—that was to say, before they realised what they ought to do in order to give their moulds a chance—they tried a metal for moulds which they had purchased from Austria. Those moulds, not being given the care that the moulds received to-day—gave approximately the same life that their moulds were giving to-day, *i.e.*, 125 to 130 lives. It might interest Mr. Pearce to know that the composition of the mould metal was 0.8 per cent. of silicon, 0.25 per cent. phosphorus, and small quantities of nickel and chromium which, in his opinion, were hardly large enough to affect the issue to any considerable extent. It might also be interesting—and he could say this because Mr. Bacon was going to tell Mr. Pearce where they disagreed with him—that they, too, had come to the conclusion that a certain manganese percentage was correct: it seemed obvious to them, too, because the manganese percentage would vary with the percentage of silicon present.

An Investigation of Mould Life

MR. BACON said the variation in the life mentioned of moulds supplied by different makers had often been ascribed to different practices in the shop itself. Recently—a matter of five or six months ago—he had found it necessary to take that matter a step further and to keep the moulds definitely in batches, and 24 new moulds were put in use and kept altogether throughout their lives. Previously moulds were constantly being replaced. They had just completed the lives of two sets of 24 moulds, all of which had been teemed in exactly the same steel, and had had the same cooling period.

In those batches of moulds there were moulds from two makers, one being themselves, and the second another branch of the United Steel Companies. In Set No. 1, 18 moulds of S.P.T. make gave a life of 126.6 (average), and the other maker's moulds, of which there were six, gave an average of 113. In Set No. 2, 21 moulds of S.P.T. make gave an average life of 128, 127, and 123; and X-maker's, 100.3. They had a third set not quite completed, but so far as it went it was of interest. Twelve moulds were given a life of 112.8, and X-maker's, 96.5. That was interesting in two ways. It showed the inferiority of the X moulds, although they were of exactly the same design. The only difference was the analysis of those moulds. S.P.T. moulds carried 1.4 per cent. silicon, and the other moulds 1.6 to 1.8 per cent. The other interesting feature—and this was the real reason that they set out to investigate in that direction—was the difference in the life between that particular batch of moulds and the other two. They were made over the same period of time, had similar analyses, and were of the same size—and they were trying to find out the reason in mould life. They achieved an average of 130, but that 130 was composed of lives varying from 80 to 240, and 180 and 190 became quite frequent. That was keeping them busy investigating, and encouraged them to proceed.

The moulds failed by both crazing and cracking. He thought they might perhaps be attaching too much importance to the question of cracking. They found they got the best results when they had 50 per cent. of the moulds failing by cracking. Referring to Fig. 2, he said that if they looked at the top line it showed failure due to cracks 52, 42, 20 down to nothing. They noticed the optimum mould value of 30 lbs. per ton coincided with 52 per cent. cracked. That confirmed their experience. If they got 100 per cent. failure due to crazing there was something wrong; the mould metal was too soft or too thin. For 100 per cent. failure by cracking they were making the mould metal too hard or the walls too thin.

Effect of Silicon

The other point was the effect of silicon. They did find that with 2 per cent. silicon a higher manganese was definitely beneficial. Since that time they had stored 1,000 moulds all treated in the same way, and they had investigated those moulds and checked the curve. There was a large number of moulds, of course, in each point: there were 1,000 moulds in each figure, and taking the manganese quantity for those moulds—0.6 per cent. manganese to 1.20—they would see there the life was orienting itself in proportion to the manganese, which accounted for the contrary results.

When they came to look into it further and put the moulds out according to the manganese and silicon, they found that whereas the high manganese was beneficial with the high silicon, definitely low manganese was beneficial with low silicon, confirming Mr. Pearce's contentions.

The other interesting point was that cracking was not quite a straight line. With no cracking at all they got a life of 146, which rather indicated that they could not go much below 0.8 per cent. silicon, because when they reached 50 cracking, they expected the mould life deteriorating.

There was also a point on the feeder-heads. Mr. Pearce had said feeder-heads reduced the mould life, which was quite true, but it was not nearly so bad as the feeder-head put on the top of the mould. They found that when on the top of the mould the moulds invariably failed there, but whereas if they put the feeder-head inside in a recess, the crack started certainly there. They overcame that by swelling the mould at that point just a little. Best of all was the casting which went inside, and in that case they found the life of the mould was not at all adversely affected.

Rolling and Forging Ingots

MR. TOM FIRTH said he was in the fortunate—or unfortunate—position of being a member of the Sub-Committee and representing the manufacturers of ingot moulds. He was the only representative on that Committee, so had his work cut out in keeping the users busy. There seemed to him to be one point which had not been mentioned, but which was of considerable importance. He appreciated very much that the larger tonnage of ingot moulds used was for rolling sizes, and it had been easier for the Committee to obtain more accurate data on moulds used for that purpose. There was also a considerable tonnage of moulds used for forging purposes, and in his experience the conditions were quite different. With a silicon content of 0.8 per cent. they could not make satisfactory moulds for forging purposes, in which the Sheffield district was particularly interested. They had to strike a happy medium between crazing and cracking, but, generally speaking, due to the mass of steel and the weight of the moulds they had to go for a very much softer iron to obtain a reasonable percentage of the moulds failing due to crazing. He wanted to correct the impression which might otherwise have been taken away from that meeting that the remarks applied to all ingot moulds. They applied to ingot moulds chiefly for rolling sizes.

Welding Defective Moulds

MR. K. R. BINKS said he noted on page 155 of the Report a reference to Reagan's Paper on "Some Factors affecting the Life of Ingot Moulds," and on looking through that Paper and its discussion at the Cleveland (U.S.A.) meeting of the American Institute of Metallurgical Engineers, the greater number of mould lives obtained was rather striking. There were mould lives of 250 to 175 ingots recorded for a 17-in. fluted mould, similar in general outline to B5 mould, described in the Ingot Mould Sub-Committee records, which had an average of 60 lives.

On further examination of that particular Paper there appeared to be a pronounced difference in the chemical composition of the mould iron—higher manganese, lower silicon, and a somewhat higher phosphorus content than any of the British mould irons—and indeed than the composition recommended in Part E of the Report. That difference in mould life and composition was so great that the Committee's views would be appreciated.

There was one other point of interest more perhaps from the operational point of view. On large moulds he believed it was possible to chip out surface defects and weld in a cast-iron filling. It would be perhaps interesting to know if any of the members present had experienced that practice.

Cracking and Crazing

MR. HINCHCLIFFE said that before answering the last question, there was a point raised by Mr. Bacon to which he would like to refer. Mr. Bacon's contribution had not been exactly a question. He was giving very valuable information which, so far as he (Mr. Hinchcliffe) knew, the Committee had not yet had. But he had said that they got an optimum of life when they got approximately 50 per cent. failure by cracking. Somewhere in the Report and in Mr. Pearce's Paper they would find it stated that the way a mould could fail was by crazing. They might think the two statements were not reconcilable, but he thought they were.

There were two ways one could improve a mould, according as to the way it failed. If it failed by splitting, they wanted a softer mould, and if it failed by surface cracking or crazing—the same thing—they wanted a hard mould or Tozer mould. To get the best life they required a mould which was between those two: they had to compromise. Although Mr. Bacon had stated that 40 to 50 per cent. of the moulds failed by cracking, those moulds possessing the sulphide grain might also be said to fail by cracking or crazing simultaneously, which was what they wished to achieve.

Referring to Reagan's Paper, Mr. Hinchcliffe thought they would find that, generally speaking, the moulds dealt with in that Paper were bigger than moulds used over here, and failure generally was by deterioration of the surface both by

crazing and by cavitation, and erosion splitting off pieces of the mould. The Committee had noted Mr. Reagan's remarks, and agreed that higher manganese and lower silicon generally was beneficial. But he did not think they could compare Reagan's results with those obtained directly in this country, because they had no opportunity of observing the conditions of surfaces in America, and did not know enough about those moulds.

Mr. Binks said he had selected Reagan's Paper as a foreign expert's view upon the mould issue. He thought Reagan's general conclusion was that cracking came from the design—some fault or defect—that failed by crazing in addition. The difference in the mould life attained at his works—200—was so great that he (Mr. Binks) thought it should be brought out fairly more strongly.

Criterion of Life

Mr. Pearce added that on the last point the life of the ingot mould was in number of heats and was not a figure which could be used, as he mentioned earlier, as between one plant and another. The true criterion, as Mr. Hinchcliffe had hinted, was the pounds of mould used per ton of steel, and they had reason to believe that that figure was very much higher for Reagan's methods, but his extra life was not really worth anything to him. In other words, the English and the American methods would compare quite favourably, but it was a fact—and perhaps Mr. Myers would agree—that the majority of British ingot moulds did fail by cracking. They believed that cracking was a matter that could be dealt with by attention to design in individual cases, and that was why they wanted Mr. Hinchcliffe to visit works to see if anything could be done to improve cracked failures in order to bring about the state of affairs whereby they could expect them to fail by crazing or by failing simultaneously at the end of their life by cracking and crazing together.

Mr. Smith said one point had occurred to him which might throw some light on the question. The failure of a mould was a relative term. What was the failure of a mould? If they watched moulds being stripped, they would see the ingots being forced out of the mould by a machine, using such force that they actually had to take a certain amount of the mould metal in doing so. Mr. Smith said that in their practice, as soon as an ingot stuck, the mould was discarded. If ever they went to Germany—and he thought the same applied to the United States, where he had seen it—they would find a majority had reached far beyond the limit they themselves thought was good practice.

Structure of Moulds

Mr. Roxburgh said, with regard to the manufacture of the ingot moulds, the question of the composition of the metal seemed to him to be unduly stressed. Naturally, the composition of any metal was important, but really it was only a guide. What to him was important was the materials which he used in order to obtain such a composition and also the ultimate structure of the metal. On the one hand they heard remarks about soft metals and hard metals, and naturally one liked to know more of the structure of the materials. He felt that in the question of the structure there were two very important points, the first being the amount of combined carbon present in the iron, and, second, the form of the graphite present. Mr. Pearce had made the point in his Paper that the refinement of the graphite was very important, and he (Mr. Roxburgh) was inclined to agree with him.

He wondered whether Mr. Bacon had based his investigations upon the fact that low silicon content associated with increased combined carbon so as to yield a material with refined graphite. He (Mr. Roxburgh) thought that if they were to start with a high carbon, low silicon material, and add to that material ferro-silicon, they could certainly improve the structure of the metal, for the reason that if, in the iron foundry, they started with a steel scrap change and added ferro-silicon, they produced a low total carbon iron. At the same time, they knew that the graphite was refined, and he wondered if ferro-silicon were added to that high carbon white iron, the structure would not be materially improved.

With regard to the question of materials used in the mixture, Mr. Pearce had indicated to them that he had made some experiments using a charge of 100 per cent. hematite; 10 per cent. steel and 90 per cent. hematite; 25 per cent. hematite scrap and the remainder hematite; and all hematite scrap; those results were enlightening. He asked if Mr. Pearce would indicate the type of hematite used, and as to whether he thought that by the blending of, for instance, East Coast and West Coast hematite, the structure of his casting would be improved.

Inoculated Irons

Mr. Hinchcliffe said Mr. Roxburgh's point about inoculated irons which were consequently white, but which were made grey by the addition of ferro-silicon, was a very interesting point. The Committee hoped to carry out in the near future an investigation on the relationship between mechanical properties of mould life and the failure of the mould. They had done a little work so far, and the indications were that for a good mould they needed an iron with high plasticity as compared with elasticity, *i.e.*, an iron which would give a high plastic permanent set in a process test. Those inoculated irons were more elastic than plastic. The percentage of the elasticity was a high percentage of the total deflection while it was in an ordinary ingot mould iron, and for that reason he did not think inoculation would improve the life of the mould. Although it must be admitted that the graphite structure was on the face of it better in inoculated iron—it would give shorter, rounder and not such straggly flakes—admittedly they would not provide such good paths for the oxidation they saw in the normal graphite-flaked ingot mould, but he thought such moulds would crack.

Mixtures Superior to Single Irons

Mr. Bacon, referring to Mr. Roxburgh's remarks as to the combined carbon, admitted they had not done anything worth mentioning in that direction. They did for a time take the total carbon and combined carbon as a matter of routine, but they did not get a result from that. Quite possibly they had dropped their investigations too early, and he thought it was worth while considering resuming those analyses.

With regard to the mixtures, they had indications from their records that a mixture of irons was superior to a single iron. The difficulty was in getting the necessary mixtures, but where possible they did prefer a mixture of the two.

They had found 10 per cent. steel scrap advantageous to mould life, and used that as a regular addition to the mixture. They used also 15 per cent. of old moulds. They had 10 per cent. steel scrap, 15 per cent. old moulds, and the balance they tried to make up of East and West Coast. With regard to those mixtures Mr. Pearce had mentioned, they used, as Mr. Pearce said, 100 per cent. of old moulds and 25 per cent. of old moulds, 10 per cent., and so on, and 10 per cent. steel scrap and 100 per cent. hematite, and as Mr. Pearce had said, they found no difference at all worth mentioning in average lives, but they found a big difference in the average lives of batches.

Mr. Hinchcliffe said that if Mr. Roxburgh was interested in the effect of combined carbon, he (Mr. Hinchcliffe) could give him a reference—the only reference he knew based on an original investigation—which was in a Paper by Prof. Svetchnikoff, published in Russia in 1935, and based on his own experiments. Prof. Svetchnikoff said a mould iron with a pearlitic structure would begin to craze before a mould iron with a ferritic structure, but crazing would proceed faster than the iron with ferritic iron, and he thought the ferritic iron was not so good as the pearlitic iron.

Cause of Growth

Dr. Jay asked if growth of those ingots was due to graphite deposited during the same time. If it was, it seemed to be a natural phenomenon. On the other hand, if oxidation was the cause of that growth, he asked if any laboratory tests had been carried out in vacuum or in neutral atmosphere, or even in a reduced atmosphere. He thought Mr. Pearce had said something about oxidation being the cause, and graphite flakes. He (Dr. Jay) would like to know how Mr. Pearce knew it was oxidation.

Mr. Hinchcliffe said the original classical work on the growth of iron had been done by Sir Harold Carpenter. He grew an iron to about 70 per cent. of its original volume, and he (Mr. Hinchcliffe) believed Sir Harold had also heated some irons in vacuum and found they grew a very small fraction of 1 per cent., due, he believed, to the decomposition of combined carbons.

Silicon and Manganese

Mr. Allison said the subject was one which obviously could only be dealt with by statistical methods. He had been responsible for making a small number of small moulds, and naturally the subject was of great interest. It appeared to him that in many of the results reported in the Report the silicon was far higher than he imagined would be a satisfactory mould. He thought Mr. Bacon's figures seemed to indicate that on the whole he leaned towards a low silicon. It appeared to him that Mr. Pearce could confirm this—that they really wanted a pearlitic iron, and if the silicon was going to range to 2 per cent. they could not have a pearlitic iron. Mr. Bacon's figures were 0.8 per cent. but he (Mr. Allison) thought that was far too low. There was another aspect. Mr. Pearce pointed out that the manganese undoubtedly graphitised at a certain point: 0.6 per cent. was a maximum graphitising point with a low silicon for a pearlitic iron.

There was one point he thought Mr. Pearce had missed in connection with the low-silicon pearlitic iron. That was the relieving of the casting stress in the mould. Mr. Pearce mentioned temperatures of 450 deg. C. and also reaching 800 deg. C., but it had been shown that the maximum stress relief in cast iron was with the temperature at just over 600 to 650 deg. Mr. Allison suggested that if they had a low-silicon mould it necessitated annealing to relieve any possible casting stress at possibly 600 to 650 deg.

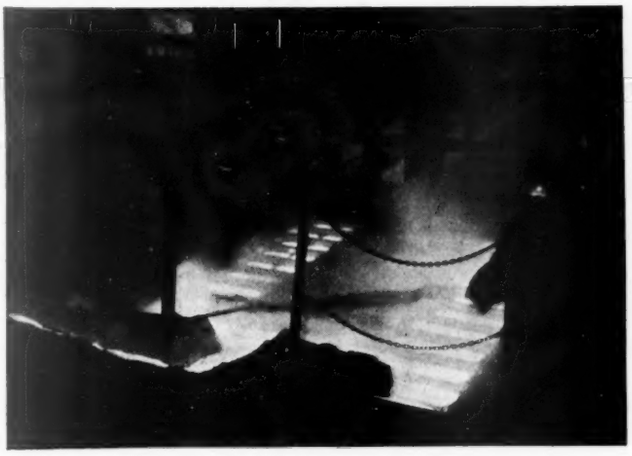
Generally speaking, high manganese in light moulds seemed to be a decided advantage. It had to be remembered that with high manganese —1 per cent. and over—there were certain stabilising effects upon the carbon, and he thought on the whole for light moulds that stabilising effect was a decided advantage. He agreed with Mr. Pearce that on the whole the tendency would be towards a lower silicon and lower manganese mould. That was to say, they wanted a pearlitic ingot mould, and one still free from casting stresses.

He had no evidence of phosphorus up to 0.2 per cent. being harmful. That might only apply to light moulds, but he thought Mr. Pearce was unduly pessimistic of the effect of phosphorus, because when they considered that cast iron was a material which consisted of a very large number of non-metallic inclusions, he did not think the phosphide eutectic inclusions were really very serious.

A responsible steelmaker had informed him that he did get a great improvement in the life of moulds by thickening out the sides of the mould towards the base.

(*Concluded on page* 320.)

Clean Iron



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W.31R

The Week's News in Brief

Trade Talk

THE ACQUISITION of the old-established Sheffield steel firm of Andrews Toledo, Limited, by Darwins, Limited, also of Sheffield, was finally completed on March 31.

THE RILEY STOKER COMPANY, LIMITED, is removing from Palace Chambers, Bridge Street, Westminster, to larger offices at 40-43, Chancery Lane, London, W.C.2, on May 16.

FOLLOWING A RECORD YEAR, the Bede Metal & Chemical Company, Limited, Hebburn-on-Tyne, has decided to give its employees a week's holiday with full pay during Race Week.

THE SUFFOLK IRONFOUNDRY (1920), LIMITED, Sifbronze Works, Stowmarket, has recently equipped an entirely new foundry for the sole purpose of manufacturing welding rods.

C. & J. HAMPTON, LIMITED, malleable ironfounders and vice makers, of Record Works, Sheffield, 9, have recently made considerable extensions to the buildings, and have transferred the head office to Bernard Road, where all communications will be delivered by the Post Office.

TAYLOR BROS. (SANDIACRE), LIMITED, railway engineers and ironfounders, of Sandiacre, recently celebrated their 80th anniversary. To mark the occasion, the employees have presented a cocktail cabinet to Mr. Arthur Taylor, Mr. Herbert E. Taylor and Mr. Leonard Taylor, directors of the firm. The presentation was made by Mr. George Russell, who has been with the company for 55 years.

THE RESULTS of the competition for a slogan for cast iron, organised by the British Ironfounders' Association, have now been announced. The first prize of £100 has been awarded to Mr. Charles Rayner, 56, Leyton Road, Southville, Bristol, the second prize of £50 to Mr. R. Mackay, The Mills, Golspie, Sutherland, and the third prize of £10 to Mr. M. J. Tulley, 400, Richmond Road, Handsworth, Sheffield. In addition, fifty consolation prizes of 10s. each have been awarded. The number of entries received was approximately 25,000.

THE SOCIAL ORGANISATION run by the employees of the United Steel Companies' Cumberland Group (Workington Iron & Steel Company, Beckermet and Bigrigg Hematite Mines, Rowrah Quarries, etc.), have decided to proceed with a £6,500 Welfare Hall, to be erected in Workington. This will incorporate a large dance floor, together with a stage and other accommodation. The sum of £3,250 towards the cost of the hall will be donated by the United Steel Companies, and the remaining £3,250 is to be handed over to the organisation as a loan, to be paid off by them over a term of years.

Personal

CAPT. H. J. BAMFORD, a director of Bamfords, Limited, agricultural engineers, Uttoxeter, has been appointed a Justice of the Peace for Staffordshire.

MR. J. M. INGRAM, representative of the Carron Company in the Midlands, has been appointed foundries commercial manager to the company at Falkirk. He succeeds Mr. Henry Bell, who resigned the position on being appointed managing director of Lane & Girvan, Limited, of Bonnybridge.

A LUNCHEON was held in Glasgow on April 6, under the auspices of the Scottish Ironfounders' Association, when ex-Provost J. K. Shanks (managing director of Cruikshank & Company, Limited) was honoured by his colleagues on his retirement from the chair of the Association, after occupying it for almost five years. He was presented with a gold-medal trout rod, reel and line. The presentation was made by Mr. Gourlay, who succeeds Mr. Shanks in the chair.

THE SCOTTISH COMMITTEE of the British Cast Iron Research Association has recommended, and the Council has approved, the appointment of Mr. T. Tyrie, B.Sc., as Superintendent of the Falkirk Technical Institute, the Association's Scottish laboratory, to succeed Mr. H. Cowan, B.Sc., who has joined Sidney Flavel & Company, Limited, Leamington. After some years' experience in the laboratories and foundries of Glenfield & Kennedy, Limited, Kilmarnock, Mr. Tyrie has for the last three years been in charge of the technical side of the foundries and enamelling shops of Walter Macfarlane & Company, Limited, Saracen Foundry, Glasgow.

Wills

FINDLAY, C. W., chairman and managing director of the Glacier Metal Company, Limited	£348,563
BARTON, JOSEPH, of Sheffield, for many years secretary and a director of Henry Bessemer & Company, Limited	£70,097
SIDDALL, C. E., for many years chairman and managing director of the Sheffield Forge & Rolling Mills Company, Limited	£27,542

Obituary

MR. WILLIAM G. CASSELLS, for many years associated with Walter Macfarlane & Company, Limited, Saracen Foundry, Glasgow, died on Sunday at the age of 70.

Company Meeting

Federated Foundries, Limited

The annual meeting of Federated Foundries, Limited, was held in Glasgow last week. MR. WILLIAM RENNIE, who presided, said that the increase in the issued capital was in respect of the acquisition of the share capital of the Burnbank Foundry Company, Limited, Falkirk, and also an interest in a foundry in the Irish Free State. The total sales for the year by all companies showed an increase of 13 per cent. over 1936, and it was satisfactory to note that the sales value for the first two months of this year showed a slight increase over the previous year. They were not pessimistic as to the future. There had been a falling off in the demand for the goods which they were producing, but they believed that before long an improvement would take place, and that there would be a gradual return to the normal demand, although the building plans passed and authorised for the three months to February, 1938, showed a reduction of 5½ per cent. over the same period of the preceding year.

Company Reports

Ideal Boilers & Radiators, Limited.—Net profit for 1937, £266,914; brought in, £267,603; preference dividend, £50,000; dividend of 10 per cent. (free of tax) on the ordinary shares, £70,000; carried forward, £414,517.

P. & W. MacLellan, Limited.—Net profit, for the year ended December 31, after providing £20,000 for depreciation, £57,498; year's interest on debentures, £6,655; debit at profit and loss brought in, £150,705; debit balance carried forward, £99,862.

Colvilles, Limited.—Trading profit and revenue from properties, £911,004; net dividends from subsidiaries, £135,126; total revenue, £1,046,130; provision for depreciation and obsolescence, £295,000; tax and N.D.C., £240,000; brought in, £247,138; ordinary dividend of 8 per cent; to general reserve, £150,000; carried forward, £288,251.

Hadfields, Limited.—Trading profit for 1937, £308,038; debenture interest and profit and loss items, £38,997; net profit, £269,040; brought in, £214,334; preference dividend, £10,125; interim dividend of 9d. per share on the ordinary shares, £60,650; final dividend at the rate of 15 per cent. on the ordinary shares (making 22½ per cent. for the year); carried forward, £291,300.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Charles Rowley & Company, Limited, 146-148, High Street, Bordesley, Birmingham.—Capital, £6,000. Brassfounders, engineers, etc. Directors: P. A. Morrison and G. S. Cottrell.

Franklin Furnace Company, Limited, 272, Slade Road, Erdington, Birmingham.—Capital, £300. Manufacturers of blowers, fans, forge plants, furnaces, etc. Directors: G. A. Franklin and L. G. Berry.

Contract Open

London, S.W., April 21.—Malleable iron brackets, for the Commissioners of Works. The Controller of Supplies, H.M. Office of Works, etc., King Charles Street, Westminster, S.W.1.

Forthcoming Events

MAY 4.

Institute of Metals:—Annual May Lecture: "Plastic Strain in Metals," by Prof. G. I. Taylor, F.R.S., at Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, at 8 p.m.

Institute of British Foundrymen

APRIL 22.

Middlesbrough Branch:—"Steel and Alloy Castings," Paper by J. E. Mercer and D. K. Barclay, at Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough.

Life of Ingot Moulds

(Concluded from page 318.)

MR. HINCHCLIFFE disagreed with Mr. Allison as regarded the annealing of low-silicon pearlitic iron, except in certain special cases where the mould failed by cracking in the first, second or third casts. He thought that all effective annealing was destroyed and was replaced by new and greater stresses by the heat-treatment due to the steel and by more or less rapid cooling after the ingot had been removed.

With regard to the moulds that had been improved by thickening at the base, it was, he believed, quite a common practice to cast a thick ridge round the bottom or top. That was only natural when one considered the stress-concentration at the entrance. It was hard to imagine a mould being ruptured in the wall, and they found in practice that most cracking did start along the bottom surface.

Phosphorus Content and Scrap Value

MR. TOM FIRTH said he would like to be enlightened on the question of phosphorus. As he understood the position up to recently the question of the phosphorous content of ingot moulds was to some extent governed by the ingot moulds' ultimate scrap value to the steelmaker. Did that appertain to-day?

MR. BACON said that if Mr. Firth was referring to a content ranging from 0.25 per cent. of phosphorus, he could tell him that the steelmakers did not care in the least. He was afraid he could not say any more than that.

MR. FIRTH replied that might be satisfactory for basic-steel makers, but what about acid makers?

MR. BACON said it was useless for them.

Vote of Thanks

Proposing a vote of thanks to Mr. Myers, Mr. Pearce, and Mr. Hinchcliffe, MR. WHITELEY said he must apologise first of all for the absence of Mr. J. B. Allan, President of the Sheffield Branch of the Institute of British Foundrymen, and as a past-President he had been asked to carry out his duties. He thanked Prof. Andrew for the welcome he had extended to them in his opening remarks, and they in turn would express their appreciation of the opportunity that had been afforded them to attend that meeting.

MR. NOBLE, in seconding, explained that he had not taken part in the discussion because, as a member of the Ingot Mould Committee, he had always plenty of opportunities of discussing the subject. The purpose of the meeting had really been to get the opinions of ingot mould makers or users.

MR. MYERS replied on behalf of Mr. Pearce, Mr. Hinchcliffe and himself.

MOULDING SANDS *for* THE FOUNDRY

The selection of a moulding medium for the foundry necessitates the utmost care and attention. Higher casting temperatures have resulted in a demand for moulding sands of greater refractoriness and permeability, to withstand these severe conditions. General Refractories, Limited, specialises in sand of this description. There is a great variety of sands and it is important to choose the one to suit your exact requirements. Some are mentioned below, but if you desire more detailed information, the Technical Department is always willing to make recommendations on hearing the conditions of individual problems.

YORKSHIRE MOULDING SAND
for Steel Castings

BRAMCOTE MOULDING SAND
for Iron and Brass Castings

THANET MOULDING SAND
for all kinds of Iron Castings

YORK YELLOW MOULDING SAND
for medium weight Iron Castings

ZENITH MOULDING SAND
for Iron and Brass Castings

MANSFIELD MOULDING SAND
for light Castings

CAVE BROWN MOULDING SAND
for medium size castings in Brass or Iron

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Telephone : *Sheffield* 31113 (6 *lines*). **GENEFAX HOUSE, SHEFFIELD, 10** *Telegrams :* *"Genefax, Sheffield."*

LONDON OFFICE : Russell House, Adam St. Strand, W.C.2. Tele hone : Temple Bar 3511. Telegrams : " Genefax, Rand-London." (Mr. A. C. Turner).

SCOTTISH OFFICE : 48, West Regent Street, Glasgow, C.2. Telephone : Douglas 6108. Telegrams : (3 lines). " Genefax, Glasgow."

SWANSEA OFFICE : Metropole Chambers, Wind Street, Telephone : 3680. Telegrams : " Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE : 9, Albert Square. Telephone : Blackfriars 6130. Telegrams : " Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE : Halifax Bldgs., Exchange Place, Telephone : Middlesbrough 3313. Telegrams : " Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE : 17, Windsor Place, Telephone : 5796. Telegrams : " Genefax, Cardiff." (Mr. F. E. Rutter).

Raw Material Markets

The Easter holidays this year will make little difference to the iron and steel markets, there being no necessity for the consuming plants to take up extra supplies to tide them over the vacation, as they are already overstocked in many cases. In view of the decision shortly expected to be made with regard to the import duty on pig-iron, imports have virtually ceased. As a result of this, and also the announcement of additional orders from the Admiralty and other war departments, the outlook is viewed with more confidence.

Pig-Iron

MIDDLESBROUGH.—A few small orders for foundry iron are being placed, but, generally speaking, there is little to be had in the way of new business. Outputs have been considerably reduced, but there is still a substantial surplus of supplies. No doubt, after the imported iron already on hand has been consumed, there will be a resumption of trade. In hematite, also, the demand is very weak from home consumers, while export inquiries are negligible. So far, consumers have not taken advantage of the producers' willingness to book orders for delivery over the third quarter of the year. Mixed numbers of hematite are quoted at 132s. 6d. per ton for delivery on the North-East Coast, 138s. in Sheffield, and 143s. 6d. in the Midlands, all less 5s. rebate.

LANCASHIRE.—Hopes are held in this area that makers of light castings are about to experience increased activity, although it must be said that there is still little evidence of this. Machine-tool makers and heavy electrical engineers are generally well employed, but the position among textile-machinery manufacturers is still far from satisfactory. Good stocks are held by most of the consuming plants, and, consequently, there is only a small amount of new business passing at the present time. The demand is expected to expand within the course of the next few weeks, as quite a number of contracts is due to expire.

MIDLANDS.—The absence of orders of any size is still apparent in this area; some consumers are taking up meagre tonnages each week, but there is a disinclination to book large orders. Producers in the Midlands will not sell for deliveries after the end of June, when prices will come up for revision. Many of the light-castings founders are working only two or three days during the week, and there is not, as yet, any indication that this position will be improved upon in the near future, although an increase in orders may be brought about if the expected change in the condition of the building industry materialises. For delivery to Birmingham and Black Country stations, Northamptonshire No. 3 foundry iron is quoted at 108s. 6d., with Derbyshire No. 3 at 111s., both less 5s. rebate. Bar iron makers are quiet, and there is no improvement in the demand for forge iron. Hematite, together with low-phosphorus iron, is now in slightly increased demand. It is anticipated that this improvement will be accentuated. Refined iron is still in poor call.

SCOTLAND.—Two small cargoes of Cleveland iron were recently shipped from the Tees to this area. This was the first iron to arrive in Scotland from the North-East Coast of England this year. These imports, however, do not indicate any revival of demand, and the market remains very quiet. Consumers are still in possession of heavy tonnages of Continental iron. No. 1 foundry iron is quoted at 120s. 6d. and No. 3 at 118s., f.o.t. furnaces. Heavy supplies of hematite and basic are being taken up by local steelworks, which are working to full capacity. For delivery in this district, hematite mixed numbers are quoted at 133s., Scottish basic at 107s. 6d., and English and Indian basic at 100s., all less 5s. per ton rebate.

Coke

Consumers of foundry coke continue to abstain from entering into new contracts, and the market is dull at the present time. Hopes are still held that prices will be reduced long before the end of the year, which is the period that makers have stated. For delivery in Birmingham and district, best Durham foundry coke is quoted at 55s. 9d., and Welsh coke at from 55s. to 62s. 6d.

Steel

Although the consumption of steel continues to be very heavy, stocks of some products on hand at the consumers' plants are sufficient to meet the demand and little new business is being transacted at the present time. In many cases, also, users have still quite substantial deliveries to take up before existing contracts are liquidated. Many consumers of semi-finished steel are in possession of large supplies of imported material and have little need to take up additional tonnages. The demand for heavy finished steel is good, but the market for lighter products, such as sheets, small bars, strip, etc., remains in an unsatisfactory condition.

Scrap

Demand is weak in nearly all sections of the iron and steel scrap market. Ironworks and foundries, particularly, are very quiet at the present time, while in many quarters there is a reduced inquiry from the steelworks. Prices of steel scrap, of course, have been stabilised, and there can be no reductions made yet in these fixed quotations. Merchants are in possession of large stocks, far greater than the current demand necessitates.

Metals

Copper.—Business has been on a fair scale in this country during the past week, and the undertone is quite firm. No doubt, the next few days will be rather quieter, with the intervention of the Easter holidays. It is understood that supplies of electro for early delivery are difficult to obtain at the present time. Continental consumers have, on the whole, made quite good purchases recently, but French business has been hampered by political unrest and strikes at many of the Parisian metallurgical works. There is little improvement in the United States industrial outlook, and trade continues to be restricted as a result.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £38 8s. 9d. to £38 11s. 3d.; Friday, £38 8s. 9d. to £38 10s.; Monday, £39 15s. to £39 17s. 6d.; Tuesday, £39 8s. 9d. to £39 10s.

Three Months.—Thursday, £38 13s. 9d. to £38 15s.; Friday, £38 13s. 9d. to £38 15s.; Monday, £40 to £40 2s. 6d.; Tuesday, £39 13s. 9d. to £39 15s.

Tin.—It is still uncertain whether Malayan tin producers will hold a referendum on the buffer pool proposals. A decision is expected to be made within a short time. No date has been fixed for the next meeting of the International Tin Committee; the last meeting should have been held in Paris last week, but was postponed as a result of the Malayan uncertainty. Chinese miners have called a public meeting for to-day (Wednesday) to consider the advisability of urging the Government to put forward a demand for increased standard tonnages under the tin control scheme. It is also expected that the meeting will discuss the proposals for a buffer pool and the desirability of Malaya withdrawing altogether from the control scheme.

A slight improvement was shown in the condition of the South Wales tinplate trade during the past week, but the industry is still employed at well under 50 per cent. of capacity. Largely as a result of the dull state of the tinplate trade, business in tin in this country has been unsatisfactory. Prices have continued to fluctuate considerably. Of the Continental countries, the Soviet Union has shown most interest in new business, and has taken up further heavy tonnages. Consumers in the United States are still adopting a cautious attitude.

Official quotations were as follow :—

Cash.—Thursday, £167 15s. to £168; Friday, £169 10s. to £169 15s.; Monday, £173 10s. to £174; Tuesday, £170 to £170 5s.

Three Months.—Thursday, £168 5s. to £168 10s.; Friday, £170 to £170 5s.; Monday, £174 10s. to £174 15s.; Tuesday, £170 15s. to £171.

Spelter.—Brassmakers have displayed rather more activity during the past week, but business is still dull, and there is no improvement among the galvanisers. The demand for high-grade zinc appears to be increasing. In the United States, only a small inquiry is in circulation.

Daily market prices :—

Ordinary.—Thursday, £13 7s. 6d.; Friday, £13 8s. 9d.; Monday, £13 16s. 3d.; Tuesday, £13 12s. 6d.

Lead.—Few long-term contracts are being arranged, consumers preferring to buy only small tonnages, while the outlook remains so uncertain. Nevertheless, business has amounted to quite a good aggregate. Consumption, generally, is reported to be satisfactory.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 3s. 9d.; Friday, £15 8s. 9d.; Monday, £16 2s. 6d.; Tuesday, £16.

Scrap.—Buyers of non-ferrous scrap have been right out of the market recently. Minor price fluctuations have taken place during the past week, generally having a downward direction, although one or two quotations show an increase as compared with the figures for last week.

Approximate selling prices for old metal :—New aluminium cuttings, £77; rolled, £63; cast, £33; foil, £88. Copper, £36 to £39; braziery, £33. Brass (clean), £22 to £25. Zinc, £7 10s. Lead, £12. Gunmetal, £37 to £38.

Notes from the Branches

Lancashire Branch (Junior Section).—The annual meeting of the Junior Section of the Lancashire Branch of the Institute of British Foundrymen was held at the Manchester College of Technology last week. Mr. O. Bateson (hon. secretary) presented the anual report, which commented on the fact that the improvement shown in the previous Session had been maintained during the present Session. The Section still managed to pay its own way, and the secretary appealed to the members to restore the conditions when attendances at the meetings of fifty and over were quite common.

A vote of thanks to the retiring officers was carried unanimously. On the proposition of the President (Mr. A. Hopwood), Mr. Bateson and Mr. Boyes were re-elected hon. secretary and hon. treasurer respectively. The Council was also re-elected.

Catalogue Received

Shot-Blast Nozzles. A leaflet received from Tools & Drawing Dies, Limited, 12-20, Pancras Street, Tottenham Court Road, London, W.C.1, outlines the potentialities of "Triamant" hard-metal nozzle for use with shot-blast apparatus. A claim is made for a minimum life of 500 blasting hours without changing, and reference is made to a figure of 2,000 hrs. Though home-made nozzles may seem cheap, one has still to consider the facts of idle time during the changing periods, and increased air and power consumption for less work, and the savings made may easily outweigh initial lay-out. These factors are well brought out in the leaflet.

A Flexible Pipe Joint

An entirely new joint for pipes has been developed by the Staveley Coal & Iron Company, which is equally adaptable to metal-spun, sand-spun or vertically-cast iron pipes. It consists of a resilient gasket and two cast-iron rings (one pressure and one tightening) within a specially-designed socket. The joint is quickly and easily made, and as quickly and easily dissembled. There are no cast threads to trap dirt; no detrimental rubbing movement (as the pressure ring does not rotate); and there is no need for large joint holes in the trench, as the spanner for tightening can be used in the usual width trench. Known as the Staveley-Freer flexible joint it is supplied for pipes of 2½-in., 3-in., 4-in. and 6-in. diameter.

Randupson Saves Time

—AND, WE REPEAT, IT ALSO SATISFIES THE PARTICULAR REQUIREMENTS OF MAKERS OF DRY SAND CASTINGS IN IRON ALLOY, CARBON STEEL OR NON-FERROUS.

THE PROCESS CAN BE ADAPTED TO ALMOST ANY CLASS OF LOAM-MOULDING —INCLUDING STRICKLE WORK. RANDUPSON ELIMINATES THE NEED FOR HEAVY CAST IRON TACKLE.

WITH THE RANDUPSON PROCESS RAMMING BECOMES A SIMPLE OPERATION DONE BY SEMI-SKILLED LABOUR WITHOUT FEAR, BECAUSE OF THE FREE VENTING CHARACTER OF THE CEMENT SAND WHEN SET.

CHILLS, AS USED IN ORDINARY SAND OR LOAM MOULDING, CAN BE USED, AS THERE IS LITTLE OR NO CHANGE IN THE TEXTURE OF METAL PRODUCED.

HINCKLEYS LIMITED
11, EAST PARADE CHAMBERS
SHEFFIELD. 1.

RAW MATERIALS—PRICE LIST

(Tuesday, April 12, 1938)

COPPER

	£	s.	d.
Standard cash	39	8	9
Three months	39	13	9
Electrolytic	43	10	0
Tough	43	5	0
Best selected	43	15	0
Sheets	73	0	0
India	56	2	6
Wire bars	44	15	0
Ingot bars	44	15	0
H.C. Wire rods	48	5	0
Off. av. cash, Mar.	39	16	4 42/92
Do., 3 mths., Mar.	40	0	11 42/92
Do., Sttlmnt., Mar.	39	16	7 42/92
Do., Electro, Mar.	44	0	1 2/23
Do., B.S., Mar.	43	18	7 5/23
Do., Wire bars, Mar.	44	8	7 1/23
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			8d.

BRASS

Solid drawn tubes	11d.
Brazed tubes	13d.
Rods, drawn	8½d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	7½d.
Yellow metal rods	6½d.

TIN

	£	s.	d.
Standard cash	170	0	0
Three months	170	15	0
English	170	0	0
Bars	172	0	0
Straits	171	10	0
Eastern	170	15	0
Banca (nom.)			—
Off. av. cash, Mar.	183	11	8 2/23
Do., 3 mths., Mar.	183	12	8 14/23
Do., Sttlmt., Mar.	183	11	1 1/23

SPELTER

	£	s.	d.
Ordinary	13	12	6
Remelted	11	5	0
Hard	11	0	0
Electro, 99.9	17	11	3
English	15	2	6
India	13	5	0
Zinc dust	19	0	0
Zinc ashes	5	0	0
Off. aver., Mar.	14	8	4 85/92
Aver., spot, Mar.	14	7	3 9/23

LEAD

	£	s.	d.
Soft foreign, ppt.	16	0	0
Empire (nom.)	16	18	9
English	18	0	0
Sheets, home	23	0	0
Do. export	19	10	0
Pipes, home	22	10	0
Do. export	20	2	6
Tea lead	32	2	6
Off. aver., Mar.	16	0	7 81/92
Aver., spot, Mar.	15	19	10 1/23

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	28	15	0 to 29	5	0	
Do., V.M. ex-whse.	28	15	0 to 29	5	0	
Rods			20	10	0	

ANTIMONY

	£	s.	d.	£	s.	d.
English	81	0	0 to 82	0	0	
Chinese, ex-whse.	63	0	0 to 64	0	0	
Crude, c.i.f.			38	0	0	

QUICKSILVER

	£	s.	d.
Quicksilver	12	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS

	£	s.	d.
Ferro-silicon—			
25%	12	10	0
45/50%	12	0	0
75%	17	0	0
Ferro-vanadium—			
35/50%	14/- lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	4/9 lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	9d. lb.		
Ferro-phosphorus, 20/25%	£21 to £22		
Ferro-tungsten—			
80/85%	5/6 lb.		
Tungsten metal powder—			
98/99%	5/7½ lb.		
Ferro-chrome—			
2/4% car.	34	15	0
4/6% car.	24	5	0
6/8% car.	24	0	0
8/10% car.	24	0	0
Ferro-chrome—			
Max. 2% car.	36	0	0
Max. 1% car.	38	5	0
Max. 0.5% car.	41	0	0
70% carbon-free	10d. lb.		
Nickel—99.5/100%	£180 to £185		
"F" nickel shot	£165	0	0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.		
Metallic chromium—			
96/98%	2/5 lb.		
Ferro-manganese—			
76/80% loose	£18 15 0 to 19	5	0
76/80% packed	£19 15 0 to 20	5	0
76/80% export	£22	0	0
Metallic manganese—			
94/96% carbon-free	1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

SCRAP

South Wales (West)—	£	s.	d.	£	s.	d.
Heavy steel, best	3	8	9 to 3	11	3	
Mixed iron and steel	3	6	9 to 3	9	3	
Heavy cast iron	3	8	9 to 3	11	3	
Good machinery	3	12	6 to 3	15	0	
Cleveland—						
Heavy steel, best	3	7	0 to 3	9	6	
Steel turnings	2	13	0 to 2	15	6	
Heavy cast iron			4	0	0	
Heavy machinery			4	5	0	
Midlands—						
Short heavy steel			3	12	6	
Light cast-iron scrap			3	2	6	
Heavy wrought iron	4	0	0 to 4	5	0	
Steel turnings	2	6	3 to 2	8	9	
Scotland—						
Heavy steel, best	3	5	0 to 3	7	6	
Ordinary cast iron	4	0	0 to 4	2	6	
Cast-iron borings	2	0	6 to 2	3	0	
Wrot-iron piling	4	5	0 to 4	7	6	
Heavy machinery			4	6	6	

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	31	0	0
Brass	21	10	0
Lead (less usual draft)	14	0	0
Tea lead	10	0	0
Zinc	7	0	0
New aluminium cuttings	69	0	0
Braziery copper	28	0	0
Gunmetal	31	0	0
Hollow pewter	130	0	0
Shaped black pewter	90	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.

Per lb. d/d buyers' works.

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
,, No. 3	109/-
,, No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
,, d/d Birm.	144/6
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
,, No. 3 fdry.	111/-
Northants forge	107/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	110/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
,, fdry. No. 3	108/6
Lincs forge	107/6
,, fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0 to 13	15	0	
Nut and bolt iron	11	12	6 to 12	2	6	
Hoops			14	2	6	
Marked bars (Staffs) f.o.t.			15	15	0	
Gas strip			14	2	6	
Bolts and nuts, ¾ in. × 4 in.			17	10	0 and up	
Steel—						
Plates, ship, etc.	11	8	0 to 11	10	6	
Boiler plts.	11	18	0 to 12	0	6	
Chequer plts.			13	0	6	
Angles			11	0	6	
Tees			12	0	6	
Joists			11	0	6	
Rounds and squares, 3 in. to 5½ in.			12	0	6	
Rounds under 3 in. to ¾ in. (untested)			11	9	0	
Flats—8 in. wide and over			11	5	6	
,, under 8 in. and over 5 in.			11	10	6	
Rails, heavy			10	2	6	
Fishplates			14	2	6	
Hoops (Staffs)			12	4	0	
Black sheets, 24g. (4-t. lots)			15	15	0	
Galv. cor. shts. (,,)			18	10	0	
Galv. flat shts. (,,)			19	0	0	
Galv. fencing wire, 8g. plain			20	5	0	
Billets, soft, 100-ton lots			7	17	6	
Sheet bars			7	15	0	
Tin bars			7	15	0	

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11d.
Wire	12½d.
Rods	13d.
Tubes	18½d.
Castings	15d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.84
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	34/6
Durham foundry	39/6
,, furnace	32/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. British Channel ports.

I.C. cokes	20×14	per box	22/6
,,	28×20	,,	45/-
,,	20×10	,,	32/4
,,	18¾×14	,,	23/5
C.W.	20×14	,,	20/-
,,	28×20	,,	42/6
,,	20×10	,,	28/8
,,	18¾×14	,,	20/9

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£11	0	0 to £12	0	0	
Bars-hammered, basis	£20	0	0 to £22	0	0	
Bars and nail-rods, rolled, basis	£19	0	0 to £20	0	0	
Blooms	£18	0	0 to £19	0	0	
Keg steel	£30	0	0 to £35	0	0	
Faggot steel	£20	0	0 to £25	0	0	
Bars and rods dead soft st'l	£19	0	0 to £20	0	0	

All per English ton, f.o.b. Gothenburg [Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

			£	s.	d.		
Apr.	7	..	38	8	9	dec.	2/6
,,	8	..	38	8	9	No	change
,,	11	..	39	15	0	inc.	26/3
,,	12	..	39	8	9	dec.	6/3

Standard Tin (cash)

			£	s.	d.		
Apr.	7	..	167	15	0	dec.	25/-
,,	8	..	169	10	0	inc.	35/-
,,	11	..	173	10	0	,,	80/-
,,	12	..	170	0	0	dec.	70/-

Spelter (ordinary)

			£	s.	d.		
Apr.	7	..	13	7	6	dec.	6/3
,,	8	..	13	8	9	inc.	1/3
,,	11	..	13	16	3	,,	7/6
,,	12	..	13	12	6	dec.	3/9

Lead (soft foreign, prompt)

			£	s.	d.		
Apr.	7	..	15	3	9	dec.	6/3
,,	8	..	15	8	9	inc.	5/-
,,	11	..	16	2	6	,,	13/9
,,	12	..	16	0	0	dec.	2/6

Electrolytic Copper

			£	s.	d.		
Apr.	7	..	42	10	0	dec.	10/-
,,	8	..	42	10	0	No	change
,,	11	..	43	15	0	inc.	25/-
,,	12	..	43	10	0	dec.	5/-

Tin (English ingots)

			£	s.	d.		
Apr.	7	..	167	15	0	dec.	25/-
,,	8	..	169	10	0	inc.	35/-
,,	11	..	173	10	0	,,	80/-
,,	12	..	170	0	0	dec.	70/-

Spelter (Electro, 99.9 per cent.)

			£	s.	d.		
Apr.	7	..	17	12	6	dec.	6/3
,,	8	..	17	10	0	,,	2/6
,,	11	..	17	15	0	inc.	5/-
,,	12	..	17	11	3	dec.	3/9

Lead (English)

			£	s.	d.		
Apr.	7	..	17	5	0	dec.	10/-
,,	8	..	17	10	0	inc.	5/-
,,	11	..	18	0	0	,,	10/-
,,	12	..	18	0	0	No	change

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908	13 2 6	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 11 0½
1909	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 16 8
1910	11 15 0	12 5 0	12 5 0	11 15 0	11 10 0	11 10 0	11 12 6	11 12 6	11 12 6	11 12 6	11 10 0	11 10 0	11 13 4
1911	11 5 0	11 1 3	10 15 0	10 15 0	10 13 9	10 10 0	10 13 9	11 0 0	11 5 0	11 5 0	11 5 0	11 7 0	10 19 7½
1912	11 10 0	11 10 0	11 10 0	11 15 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 12 6	12 18 0	12 15 0	12 2 11½
1913	12 15 0	12 15 0	12 15 0	12 11 3	11 18 0	11 15 0	11 15 0	11 15 0	11 15 0	11 3 0	11 0 0	11 2 6	11 18 4
1914	11 7 0	11 7 6	11 7 6	11 5 7½	11 2 6	10 15 0	10 15 0	12 17 6	14 2 0	13 7 0	11 15 7	11 2 6	11 16 0
1915	11 10 8½	13 12 6	14 8 9	15 0 6	17 17 6	20 17 6	20 17 6	20 6 3	17 12 6	18 1 0	22 13 9	25 2 0	18 3 4½
1916	26 5 0	27 12 6	28 0 0	28 5 0	29 0 0	29 0 0	28 15 0	28 3 0	28 15 0	28 15 0	28 15 0	28 15 0	28 6 8½
1917	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 0 0	28 0 0	28 0 0	28 11 8
1918	28 5 0	28 15 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	28 13 4
1919	29 0 0	29 0 0	29 0 0	28 0 0	28 10 0	27 7 6	27 5 0	29 3 0	32 0 0	33 0 0	36 10 0	40 8 4	31 8 3½
1920	46 10 0	49 15 0	53 15 0	56 0 0	55 10 0	54 10 0	52 10 0	48 10 0	44 3 4	39 2 6	35 17 6	30 8 0	47 4 3
1921	23 10 0	25 17 6	24 5 0	23 3 4	22 0 0	22 0 0	23 10 0	21 12 6	20 0 0	18 15 0	18 3 9	17 2 0	22 1 7
1922	16 17 6	15 13 9	16 3 0	16 10 0	16 4 4½	15 15 6	15 16 3	16 16 0	16 8 9	16 6 3	17 1 0	17 7 6	16 7 5½
1923	18 3 1½	19 1 11½	19 8 0	19 10 0	19 7 0	19 1 3	18 0 0	18 13 1½	19 0 0	19 3 9	19 2 6	18 19 4½	18 10 2
1924	18 13 6	18 9 4½	18 5 0	17 15 11½	17 3 0	17 19 4½	18 7 6	18 8 1½	18 8 1½	17 19 6	17 11 3	17 10 0	18 0 10½
1925	17 8 6	17 1 6	16 9 4½	16 12 0	16 9 8½	16 9 4½	16 0 6	16 1 10½	16 5 0	16 7 0	16 12 6	16 15 0	16 11 0½
1926	16 14 4½	16 5 7½	16 0 6	15 11 10½	15 11 3	16 0 0	16 16 0	16 18 9	16 14 0	16 18 9	17 10 0	16 19 0	16 10 0½
1927	16 1 1	15 7 6	15 3 3	15 3 1½	14 14 4½	14 11 6	14 1 10½	14 0 0	13 19 6	13 16 10½	13 13 1½	13 3 9	14 9 10
1928	13 0 0½	13 2 6	13 6 0	13 2 6	13 3 0	13 6 9	13 11 3	13 10 0	13 10 7½	13 12 6	13 11 6	13 10 0	13 9 9½
1929	13 11 0	13 13 1½	13 12 9½	13 10 11½	13 9 3	13 8 9	13 11 6	13 7 6	13 7 6	13 5 6	12 18 9	12 12 9½	13 7 5½
1930	12 5 0	11 15 0	11 19 6	11 18 7	11 18 0	11 17 6	11 17 6	11 17 6	11 16 3	11 12 6	11 8 9	11 5 0	11 15 11½
1931	11 4 0	11 0 0	11 0 0	11 0 0	10 13 9	9 18 9	9 13 0	9 5 3½	8 19 0½	9 16 0	9 8 9	9 4 0½	10 1 10½
1932	9 2 9	9 14 4½	9 16 0	9 13 9	9 12 6	9 12 6	9 11 0	9 4 4½	9 11 3	10 12 6	11 5 0	11 7 0	9 18 7
1933	11 15 0	11 15 0	11 15 0	11 15 0	11 17 6	12 4 0	12 10 0	12 10 0	12 12 6	12 15 0	12 15 0	12 15 0	12 4 11
1934	12 15 0	12 15 0	12 15 0	12 17 6	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	12 18 6½
1935	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 2 6	13 5 0	13 7 6	13 1 3
1936	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 14 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	13 14 5
1937	14 0 0	14 0 0	15 10 0	17 0 0	19 10 0	19 10 0	19 10 0	19 10 0	19 10 0	19 10 0	19 10 0	19 7 0	18 0 7
1938	18 10 0	18 10 0	18 10 0	—	—	—	—	—	—	—	—	—	—

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(A remittance should accompany instructions.)

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FOREMAN or Assistant desires change. Age 32. Experienced green, dry sand, jobbing, repetition. Ordinary high-duty cast iron. Machine tools; general engineering. First-class references. Guaranteed to get results.—Box 858, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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AN opening for an Engineer in an established business connected with Boiler Grates, able to control inside detail work, £1,000 required under own control. Principals only.—Reply Box S., c/o BROWN'S, 37, Tothill Street, London, S.W.1.

ASSISTANT FOREMAN, experienced pump and engine castings. Full knowledge modern machine moulding and pattern design for production work. Also energetic Pattern-maker.—Apply Box 866, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2

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FOREMAN PATTERNMAKER required for large works in India. Candidates should have good experience in all branches of dry, green and loam moulding, be able to control and organise labour and have good knowledge of rate fixing and estimating. Experience in works engaged in the manufacture of cast-iron pipes and specials will be considered an advantage. Salary according to experience, free quarters provided, free passages, provident fund. Five-year agreement. Apply, by letter, with copies of testimonials, stating age, whether married or single, to: "ARBOUR," c/o ABBOTT, Eastcheap, London, E.C.3.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOUNDRY MANAGER, age 40, requires position. Experience in marine engineering, machine tools and general jobbing foundry. Several years' supervisory experience, capable of taking full charge of important engineering foundry. (320)

YOUNG Foundry Metallurgist desires situation as Foundry Technical Assistant, or similar position. Excellent laboratory, works and technical training, also steelworks experience. (321)

SITUATIONS VACANT AND WANTED—*Contd.*

WANTED.—Machine Shop Manager for large ironfounders in India producing general castings and pipes and specials. Applicants must be good organisers with an up-to-date knowledge of modern machine-shop practice, and be competent to take complete control. Age about 35 years or under, five years' agreement, good salary and prospects, free passages, unfurnished quarters and medical attention, provident fund, and home leave on re-engagement. Apply by letter stating age and whether married or single to: "MACHINE," c/o WM. ABBOTT, LTD., 32, Eastcheap, London, E.C.3.

AGENCY

LONDON Agency desired for a Foundry who are on the Government Lists, and who can undertake Repetition Work in Grey Iron and Aluminium.—Box 872, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & CO., LTD., Station Works, Ecclesfield, Sheffield.

'Phone **98** Staines.

2½- AND 1½-TON Morris Overhead Hand Cranes.

Tilghman Vertical Belt-driven Air Compressor, 130 c.f. at 100 lbs. w.p.

Riveted Steel Air Receiver, 6 ft. 6 in. by 2 ft. 6 in., 100 lbs. w.p.

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ROOMS size, 12 ft. by 12 ft., 12 ft. by 9 ft., and 6 ft. by 6 ft.

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Cabinet: 6 ft. by 4 ft.; 4 ft. 6 in. sq. by 3 ft. 6 in. sq., and 30 in. dia.

Table: 9-ft. Guttman.

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Sand Mills: 7 ft. 6 in., 7 ft., 6 ft., 5 ft. and 4 ft. dia. pans.

Cupolettes: 10 cwts., 15 cwts. and 20 cwts.

Cupolas: 2 and 3 tons.

Morgan Tilting Furnaces: 250 and 400 lbs.

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Large and varied stock of OIL AND PETROL STORAGE TANKS, lying in various parts of the country.

Steel-framed BUILDING, about 177′ long x 144′ x 22′ to eaves.

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'Phone: 287 SLOUGH

TABOR Portable Shockless Moulding Machine for 18″ × 36″ boxes Price £60

TABOR Portable Shockless Moulding Machine for 24″ × 48″ boxes Price £90

Portway Core Stove with thermostat.....Price £20

Ladle, 5-tons capacity, NEW Price £44

Also 6, 7, and 8-tons capacity Ladles, CHEAP

Large stock of TILTING FURNACES

Several small Foundry Grinders at £10 each

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